# Design of Transmission Line Tower and Its Performances

by

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Dissertation submitted in partial fulfillment of
the requirements for the
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(Civil Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

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Tronoh,Perak Darul Ridzuan

September 2011

## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for work submitted in this project, that the original work is my own concept as specified in the references and acknowledgements and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(MOHD SHAFIQ BIN MOHD ZULKIFLI)

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# ABSTRACT

Many tower failure cases are reported due to several conditions such as due to icing, broken wire condition, earth wire broken, vandalism and also earthquake. The tower failures can be avoided by identifying the damage mechanism and improving the tower design. The tower can be designed using different codes of practices. However, currently, there's no comparison being made regarding the load acting on tower bodies if the tower design according to different codes of practices.

In this thesis, an attempt has been made to do the comparison of the loads acting on the tower body based on 3 different codes which are BS8100, IS 802 & MS 1553. The design load and resistance formulation have been improved based on research and have been included in the latest revisions of the codes of practices. The design also take account the factor of safety, reliability and security. This objective of this thesis is met by choosing one typical Double Circuit Lattice Steel Tower which is 275kV. This tower is assumed to be located at Peninsular Malaysia. The dimension and tower shape will remain same for load design using different codes of practices.

The wind loading acting on each tower panels will be computed using Microsoft Excel. The entire wind load computations have to be repeated simultaneously within the design stage. The tower model also will be analyzed using Staad Pro software using different loading condition. Analysis of each of these towers has been carried out as a three dimensional structure. Then, the tower deflection will be monitored and analyzed to see which cases are most critical based on the load acting on the tower body. Then, all these towers will be compared and analyzed based on condition for all codes of practices.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Project

Energy is important very in our daily life. Electricity is one of energy form. Electricity use is the foundation for much of our way of life. We use electricity for the home heating, lightning, television, radio and many more. Electricity is produced in power station that usually located away from residential and urban area. In order to transport the electricity from power station to substation, we need a high voltage transmission line system. In Peninsula Malaysia, the high voltage transmission line operated and owned by Tenaga Nasional Berhad(TNB). In Sarawak, it's owned by Sarawak Electricity Supply Corporation (SESCO) while in Sabah it's owned by Sabah Electricty Sdn Bhd (SESB). In Malaysia, the transmission line system operates at high voltage such as 66kV, 132kV, 275kV, and 500 kV. Some distribution system operates at lower voltage such as 11kV, 22kV, 33kV. These voltages depend on the country electric supply requirement. Different country will have different electric supply requirement.

The primary components of transmission line system include transmission line tower, conductors, ground wires, vibration damper and also insulator. Transmission line tower is used to carry transmission lines and high voltage distribution line across lands, rivers and roads. Lattice Steel Towers (LST) are the common types of towers used in high voltage transmission lines in Malaysia. LST consist of a steel framework of many structural components that are bolted or welded together. Many of transmission line tower have been designed using a uniform code of design practice such as BS 8100, IS 802, MS 1553:2002 and ASCE 10-97. Different codes of practice will have different equations and methods of calculation. It can also have different coefficient such as wind speed pressure and topographic factor. This different coefficient will have an effect on tower design.

In current uniform code of design practice that followed by many countries, there are no established criteria for obtaining an optimal tower design with regard to its weight and geometry. Member sectional areas are usually treated as design variables for weight optimization (Rao, 1995).This design optimization will give a lot of advantage such as it can reduce the cost.

Staad Pro Modeling will be used to analyze one typical structure in Peninsular Malaysia to check whether it's safe or not due to typical tower failure causes such as icing, broken wire condition, earth wire broken and earthquake. In this project, the modeling analysis will use different load combination to determine the tower member's deflection due to selected condition. From this modeling also, the tower optimization study will be conduct to determine the best tower design.

## 1.2 Problem Statement

In Malaysia, there are not many studies conducted on transmission tower failure due to several conditions such as due to icing, broken wire condition, earth wire broken, vandalism and also earthquake. When such failures occur, it usually will cause a cascading failure that will involve a number of adjacent towers along the transmission line. By doing this project, author believed the modeling on existing structure can be conducted and the result can be analyze to see whether the structure can sustain the load that come from different type of failure conditions. In many countries, different code of practice being used to design the transmission line tower. Typical code that being used such as BS 8100, IS 802, MS 1553:2002 and ASCE 10-97. Different codes maybe will give different design load on tower design. Clear study need to be conducted to see difference on tower design using different design code of practice. Based on this project also, the performance of the typical transmission line tower can be evaluated.

## 1.3 Objectives

The objectives of this project are:

i. To analyze the failures of Transmission Line Towers and identify the important damage mechanisms.

ii. To study the types, geometry, materials used and the foundation of transmission line tower that being used in Malaysia.

iii. To determine the load acting on transmission line tower using 3 different codes which are BS 8100, IS 802 and MS 1553:2002.

iv. To perform the Staad Pro modeling on 275 kV double circuit lattice steel tower and to analyze the design using different codes of practices.

## 1.4 Scope of Study

For the first objective, research will be conducted to study the different types of failure that usually occur on the transmission line towers and the important mechanisms that cause the failure also will be identified based on this research. For the second objective, research will be conduct to study the criteria of transmission line tower used in Malaysia in term of types, geometry, materials used, and foundation type. For the third objective, one complete design of loading acting on tower will be calculated using BS 8100. After that, the comparison will be done using another 2 codes (IS 802 & MS 1553:2002) to see which codes will give minimum loading acting on tower body. For the fourth objective, a few typical transmission line towers used in Malaysia will be choose and the tower modeling will be perform based on the complete loading design and several failure conditions.

## 1.5 Relevancy of the Project

This project is relevant because it analyze different types of transmission line tower failures in order to come out with solution to reduce the number of case of transmission line tower failures/collapse. Then, it also reviews on the loading calculation for tower body design based on different codes of practices. The comparison between the load designs based on different codes will help the structural engineer to determine which codes will produce minimum loading acting on the tower body. By using minimum loading, it can help to optimize the tower design. By doing the Staad Pro modeling, we can monitor whether the tower can sustain the load acting on the tower or not.

## 1.6 Feasibility of the Project within the Scope and Time Frame

This research is feasible to be conducted using Staad Pro software that available in Civil Engineering Department. The scope of study will be focused on transmission line tower used in Malaysia. The study will be divided into a few stages. The first stage is by doing research regarding the types, geometry, materials and foundation of transmission line tower used in Malaysia. The second stage is doing the loading calculation based on different codes of practice. The result will be compared and minimum loading will be determined. The third stage is to model the tower structure using Staad pro software. This tower model will be analyzed using different loading and see whether the tower can sustain the load or not. Finally, the result will be analyzed and conclusion will be made. This project can be complete within given time frame for Final Year Project 1 and Final Year Project 2.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

In Malaysia, the transmission line system operates at high voltage such as 66kV, 132kV, 275kV, and 500 kV. Some distribution system operates at lower voltage such as 11kV, 22kV, 33kV. The primary components in transmission are transmission tower, conductor, insulator, ground wire and vibration damper. These components are required to ensure successful of electricity delivery from power station to substation that are located at residential and urban areas. The design of transmission line tower is based on minimum weight to minimize the cost. The typical tower used in Malaysia is lattice type consisting legs, primary/secondary bracings and cross arms (Rao, 2010).

## 2.2 Transmission Line Components

### 2.2.1 Tower (Types & Materials)

There are many types of transmission tower design. The structures come in many varieties of styles such as lattice towers, guyed poles or tubular tower. They can be made from a few types of materials such as metal, galvanized steel, aluminums, concrete, wood and composites (Pohlman, 2006).Structures vary considerably in how they respond to load depending on their style and material contents. Some of the structures can be rigid and also flexible due to load.

Lattice Steel Towers (LST) and Tubular Steel Tower (TSP) are two common types of transmission tower used in Malaysia. The framework for LST made from steel and consist many structural components that are bolted or welded together. These types of towers can be designed to carry either one (single circuit) or two (double circuit) electrical circuits. For the double circuit towers, it typically holds the conductors in vertical arrangement. Double circuit towers are usually taller than single circuit towers. Single circuit towers hold the conductor in horizontal arrangement. Usually, single circuit Alternating Current (AC) tower consists of 3 phases.

### 2.2.2 Conductor

In transmission line system, conductor can be divided into two parts which are phase conductor and ground conductor/wire. The function of phase conductor is to transmit electricity in the transmission line system. The ground wire function as a protection from induced lightning strikes that otherwise will strike the phase conductor. The most common materials used as a conductor are aluminum, copper and steel. Phase and ground conductor usually consist multiple strands of aluminum, copper or steel. The conductors are stranded because it give flexibility and also provide mechanical strength. Usually a central wire surrounded by successive layer of wires containing 6,12,18,24 wires. All conductors contain electric charge which will move when electric potential difference measure in volts is applied across separate point on the materials.

There are 4 major types of overhead conductors used for the electric transmission line system (Trash, 2003) :

- AAC - All Aluminum Conductor
- AAAC - All Aluminum Alloy Conductor
- ACSR - Aluminum Steel Reinforced
- ACAR – Aluminum Conductor Aluminum- Alloy Reinforced

AAC is low cost conductor that offers conductivity of 61.2% International Annealed Copper Standard (IACS) and it also has good corrosion characteristics. It is usually selected for applications requiring high conductivity and moderate strength (Hafiz, 2005). AAAC provide good combination of tensile strength and conductivity. This type of conductor has high strength, large current carrying capacity, anti crush, and is corrosion proof with simple structure. ACSR made of all aluminum and it consist a solid or stranded galvanized core surrounded by one or more aluminum layers. It has high tensile strength and also light weight. ACAR have a central core of alloy of aluminum surrounded by layers of aluminum conductor. It gives better electric conductivity, smaller size and lighter compared to ACSR type.

In Malaysia, Tenaga Nasional Berhad (TNB) used a standard conductor for 275kV transmission line which is (Hafiz, 2005)

i. Phases Conductor - ACSR Zebra ($200mm^2$) or ACSR Batang ($300\ mm^2$)

ii. Earth wire - ACSR Skunk ($60mm^2$)

Conductors are arranged in phases in the transmission line. As the voltage increases, the phases must be separated by a spacing to prevent the interference or arching happen. The conductor spacing can be calculated using a two formulae which are Mecomb's Formula & Still's Formula:

**i. Mecomb's Formula**

Spacing (cm) = $0.0348V + 4.01(\frac{D}{W})\sqrt{s}$

Where: V = Voltage (kV)
D = Conductor Diameter (cm)
s = sag (cm)
W = Weight of conductor (kg/m)

**ii. Still's Formula**

Spacing (cm) = $50.8 + 1.814V + [\frac{L}{27.8}]^2$

Where: L = Average span length (m)

V = Voltage (kV)

### 2.2.3 Insulator

Insulators are used to support the conductor in transmission line. Insulator usually can withstand normal operating voltage and surges due to switching and also lightning strike. These insulator will maintain good clearance between phase conductors with the tower and as well as between conductors itself. There are a few types of insulator that being used in transmission line. Suspension type insulator usually used for voltages above 33 kV and this type suspends the conductor below the structure. Horizontal post type insulator supports the conductor to the side of the tower and usually used for 11kV to 150 kV transmission line. Pin type insulator used for 400 V to 33 kV transmission line. So, for 275 kV, they usually used suspension type of insulators. Porcelain or toughened glass usually used as a material to made insulator. However, newer insulators are composed of polymer and silicon which more light weight and able to resist from shattering. Choice of insulator will be based on transmission line voltage, availability, price and easy for maintenance.

According to IS 802(Part 1/Sec 1):1995, wind load on insulator strings "Fw1" shall be determined from the attachment point to the centre line of the conductor in case of suspension tower and up to end clamp in case of tension tower in direction of the wind.

### 2.2.4 Sag Tension Calculation

Sag tensions are calculated by using the parabolic equations as discussed in the IS 5613: Part 2: Sec 1:1989 by developing integrated program on Microsoft Excel for both conductor and ground wire (Gupta, 2005).

Parabolic Equation:

$$F_2^2 . (F_2-(K-\alpha .t .E))= [ L^2 . \delta^2 . q_2^2 .E /24 ]$$

$$\text{Take } K = F1-(L^2 . \delta^2 . q_0^2 .E / 24. F_1^2)$$

### 2.2.5 Vibration Damper

Vibration damper is one of the components of transmission line system. Vibration damper being used to absorb wind induced vibration (Aeolian vibration) of transmission line conductor. "The conductor vibration results in cyclic bending of the conductor near hardware attachments, such as suspension clamps and consequently causes fatigue and strand damage" (Sun & Yung, 2003). For the damper weight, it's made from cast iron and for the clamp it's usually made from aluminum alloy. The nut and bolt is made up of galvanized or stainless steel.

When a vibration wave passes the damper location, the clamp of a suspension type damper will oscillates up and down that can cause flexure on damper cable and it will create relative motion between the damper clamp and damper weight. The energy stored from vibration wave is dissipated to the damper in form of heat. The damper will become effective when the response characteristics become consistent with the frequency of conductor. The most common type of vibration damper used in transmission line is Stockbridge type.

The frequency of vibration of the conductor is directly proportional to the wind velocity and inversely proportional to the conductor diameter (Sun & Yung, 2003). Higher wind velocity will produce higher frequency of vibration in conductor. The equation is:

$$\text{Vibration Frequency (Hz)} = \frac{0.185v}{D}$$

Where: v = wind velocity (m/s)

D = conductor diameter (m)

### 2.2.6 Overhead Ground Wire (OHGW)

To protect transmission line tower and conductors from lightning strike, Overhead Ground Wire (OHGW) will be used. This ground wire will be placed on top of tower structure and being grounded. It also becomes important part of the earthing system and it's important for the protection system. Usually, the tower leg will be connected to the earth electrodes. The earth wire intercepts practically all the lightning strikes and the charge is conducted to the ground. This scheme of protection from lightning was satisfactory but there had been instances of extensive structural damages to transmission line tower due to lightning strikes (Nair, 2005)

The possibility of bending of tower members at the tower peak due to lightning strike was brought by Gopalan(1979). He showed analytically that the tower peak members can get damaged due to bending caused by attractive forces between the tower members when they carry lightning strikes. The liability to such failures is more if the tower is tangent tower and being installed at the peak of hill which the transmission line traverses (Nair, 2005). Generally for a 275 kV transmission line, galvanized steel wire having diameter 0.978 cm, weight 0.329 kg/m and ultimate tensile strength of 3612.5 kg is use as a ground wire. Over the last couple of decades, extra ground wires which install on the top and below bottom phase conductor are applied to improve the lightning shield performance through computer simulation analysis (Metwally & Heidler, 1999) .

When the lightning strikes on the earth wire at mid span, wave are produced and it will travel in opposite direction along the line reaching the adjoining towers. The ground wire is effective only when the tower footing resistance is sufficiently low. This can be reducing by two methods (Hafiz, 2005):

i. **Driven Rods** : Galvanized iron pipes or rods are driven into the earth up to depth at least 3 meters and the earth is treated with salt and charcoal.

ii. **Counter-Poise**: In rough terrain where it becomes difficult to use driven rods, a copper wire mesh with size (1m x 1m) used at depth about 1m.

## 2.3 Ground & Minimum Clearance

For security reason, the Energy Commission of Malaysia provide the minimum clearance from ground based on Electricity Regulations 1994 for transmission line. The ground clearances measured from lowest phase in transmission line to the ground level. The minimum clearance of the lowest conductor from ground for high voltage supply shall be as shown in Table 2.1.

| Operating Voltage of the lines | Clearence from Ground (As provided for in the Electricty Regualtions 1994) | | |
|---|---|---|---|
| | Over Roads (metres) | Other than over roads (metres) | In positions inaccessible to vehicular traffic (metres) |
| 11 kV | 5.79 | 5.49 | 4.88 |
| 22 kV , 33 kV, 66 kV | 6.1 | 6.1 | 5.18 |
| 132 kV | 6.7 | 6.7 | 5.79 |
| 275 kV | 7.0 | 7.0 | 7.0 |
| 500 kV | 7.3 | 7.3 | 7.3 |

**Table 2.1: Minimum Clearance of the Lowest Conductor from Ground for High Voltage Supply Lines in Malaysia**

The minimum clearance of any building or structures from high voltages supply lines (transmission line) ,apart from a substation building, it sould be not less than 4.57 metres.

## 2.4 Design & Optimization Of Lattice Steel Tower

Lattice steel tower are used widely all over the world for telecommunication and transmission line. These type of tower usually are mass produced and there the user organization call for competetive designs in order to keep the weight of each type of tower to a minimum (Natarajan P. R., 1993). A high voltage transmission line structure is a complex structure in that its design is characterized by the special requirements to be met both electrical and structural points of view (Rao, 1995).

The main considerations for the tower configuration are (Rao, 1995) :

i. The specified electrical clearance(spacing between conductor)
ii. Tower type
iii. Wind pressure
iv. Maximum & minimum temperature condition
v. Possible ice load on conductor
vi. Ground wire & terrain profile

The increased demand in the power supply and changing global weather patterns means this tower require upgrading to carry the resultant heavier loading. The failure of single tower can rapidly propagate along the line and result in severe damage that can costs in millions (Albermani, Mahendran, & Kitipomchai, 2004).

Current design practice usually is based on code of practice such as BS 8100, IS 802 and ASCE 10-97. In these codes of practice, they show the method and equation/coefficient for wind speed pressure calculation, wind loading on tower components (conductor, ground wire, insulators) and also the load due to icing. There are 3 types of loads acting on tower such as random loads, permanent loads and maintenance load (Natarajan P. R., 1993). Random loads usually due to climatic conditions such as wind, icing and temperature change. This load will act externally on the tower structure. Permanent loads will acts continuously on the tower structure. The load come from self weight of tower and tower components such as insulator, conductor, ground wire and vibration damper on the conductors. Maintenance load considered as additional load to permanent load because this load come only during maintenance operation of the tower.

In the design of transmission line, most calculations are based on static load cases. The environmental load cases are based on statistical data of wind and ice accretion. They provide a good estimate of the extreme forces that a transmission line is subjected to during its services life. In certain circumstance, the dynamic effects also need to be examined. A good example of this would be when a transmission line is subjected accidental loads such as shock load induced by conductor ruptures. The occurrence of this type of loading event is rare but unpredictable and the amplitude of forces generated is significant (Clure & Lapointe, 2003).

The loading criteria for the transmission tower given in IS 802(Part 1/Sec 1):1995 is as follows:

i. Reliability
ii. Security
iii. Safety

Reliability of a transmission line system is the probability that the system would perform its function/task under the designed load conditions for a specific period. In simple terms, the reliability may be defined as the probability that a given item will indeed survive a given service environment and loading for a prescribed period of time. The reliability requirements can be refer in clause 4.2 and 12.2.1 in IS 802(Part 1/Sec 1):1995.

Security of a transmission system is the ability of a system to be protected from any major collapse such as cascading effect, if a failure is triggered in a given component. Security is a deterministic concept as opposed to reliability which is a probalistic. The security requirements can be refer in clause 4.3 and 12.2.2 in IS 802(Part 1/Sec 1):1995.

Safety of transmission system is the ability of a system not to cause human injuries or loss of life. It relates, in this code mainly to protect of workers during construction and maintenance operations. The safety requirements can be refer in clause 4.4 and 12.2.3 in IS 802(Part 1/Sec 1):1995.

For the tower design optimization, weight and geometry always become important part for the optimization process. Member sectional areas are usually treated as design variables for the weight optimization. The joint coordinates are included as a decision variables n the case of shape optimization (Rao, 1995) . The following parameters used in tower optimization study:

- Conductor tension
- Ground wire tension
- Tower base width
- Tower width at bottom cross arm level
- Tower width at tower top
- Panel bracing angle

The analysis of a structure like the transmission line tower having large number of members, the effect of flexure is not significant and it is generally analyze as a truss with many members. In the static analysis of the tower, the primary loads that are considered are the wind and the dead weight loads with appropriate factors of safety (Rao, 1995). Figure 2.1 show the example of main electrical and structural design parameters for typical lattice steel tower:

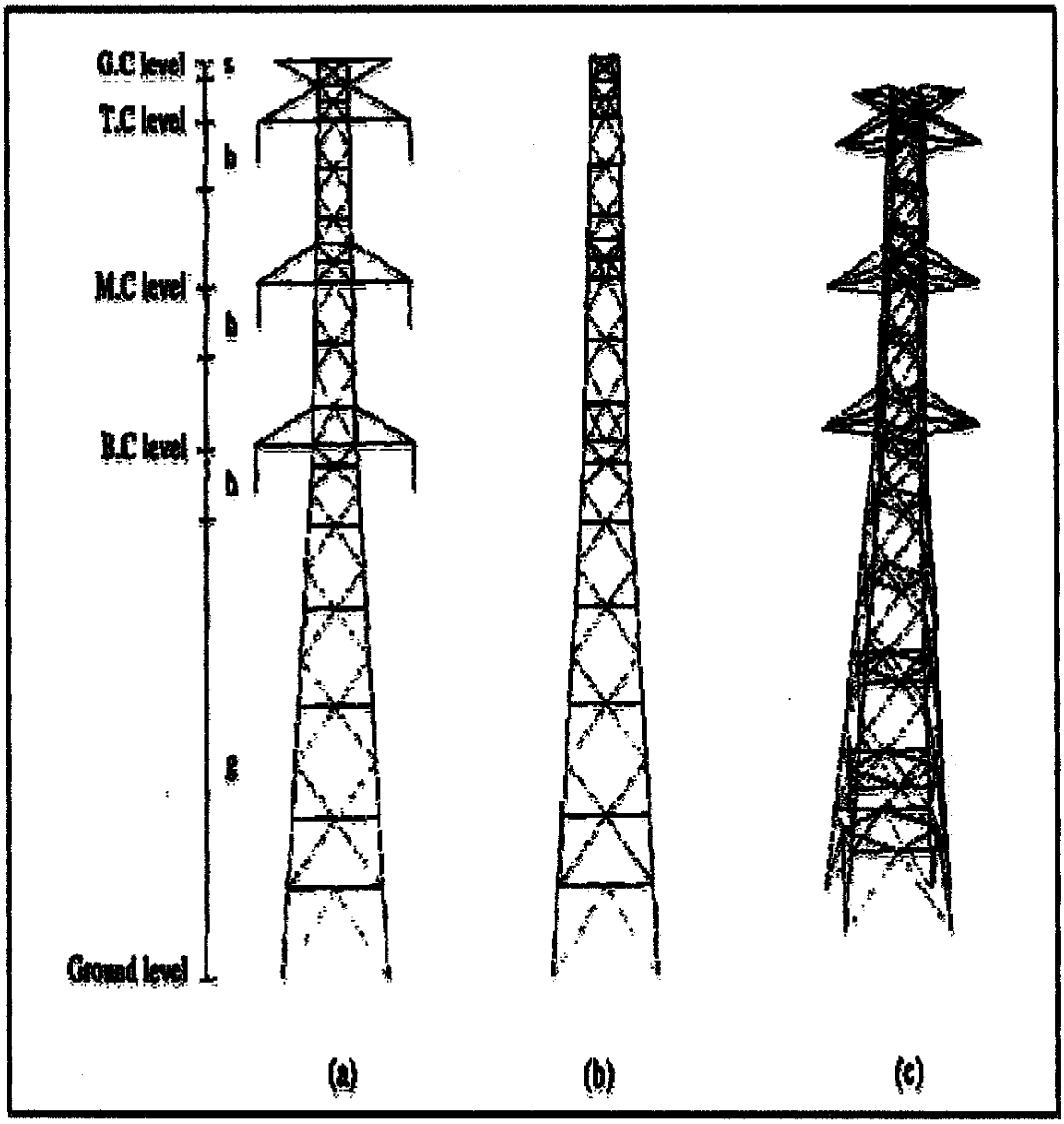


**Figure 2.1: Transmission Line Tower (Rao, 1995) .**
**(a) Transverse face (b) Longitudinal face (c) 3D view**

Where: g = Ground clearance

h = insulator length + conductor sag

s = ground wire sag

B.C = bottom cross arm

M.C = Middle cross arm

T.C = Top cross arm

G.C = Ground wire cross arm

| Item No | Parameters | Specification |
|---|---|---|
| 1 | Tower type/Circuit/Tower | 400 kV Double tangent |
| 2 | Angle of deviation | $2^{\circ}$ |
| 3 | Ground clearance | 8.84m |
| 4 | Conductor | |
| | Diameter | 31.77mm |
| | Unit weight | 2.002 kg/m |
| | Area of cross section | 5.97 $cm^2$ |
| | Breaking capacity | 16280 kg |
| | Coefficient of linear expansion | 0.1935 x $10^{-4} deg^{-1}$ |
| | Young's Modulus | 0.686 x $10^6$kg $cm^{-2}$ |
| 5 | Ground wire | |
| | Diameter | 11.0 mm |
| | Unit weight | 0.7363 kg/m |
| | Area of cross section | 0.578 $cm^2$ |
| | Breaking capacity | 6950 kg |
| | Coefficient of expansion | 0.115 x $10^{-4} deg^{-1}$ |
| | Young's Modulus | 0.1933 x $10^7$kg $cm^{-2}$ |
| 6 | Insulator | Suspension type |
| 7 | Shield angle | 20° |
| 8 | Line span | 400m |
| 9 | Weight span | 600m |
| 10 | Wind pressure | |
| | Conductor & ground wire | 45 kg/$m^2$ |
| | Tower members | 195 kg/$m^2$ |
| 11 | Temperature | |
| | Maximum | 65° |
| | Minimum | 0° |

**Table 2.2: Main Electrical and structural design parameters of the example tower (Rao, 1995)**

## 2.5 Average Wind Speed Convertion

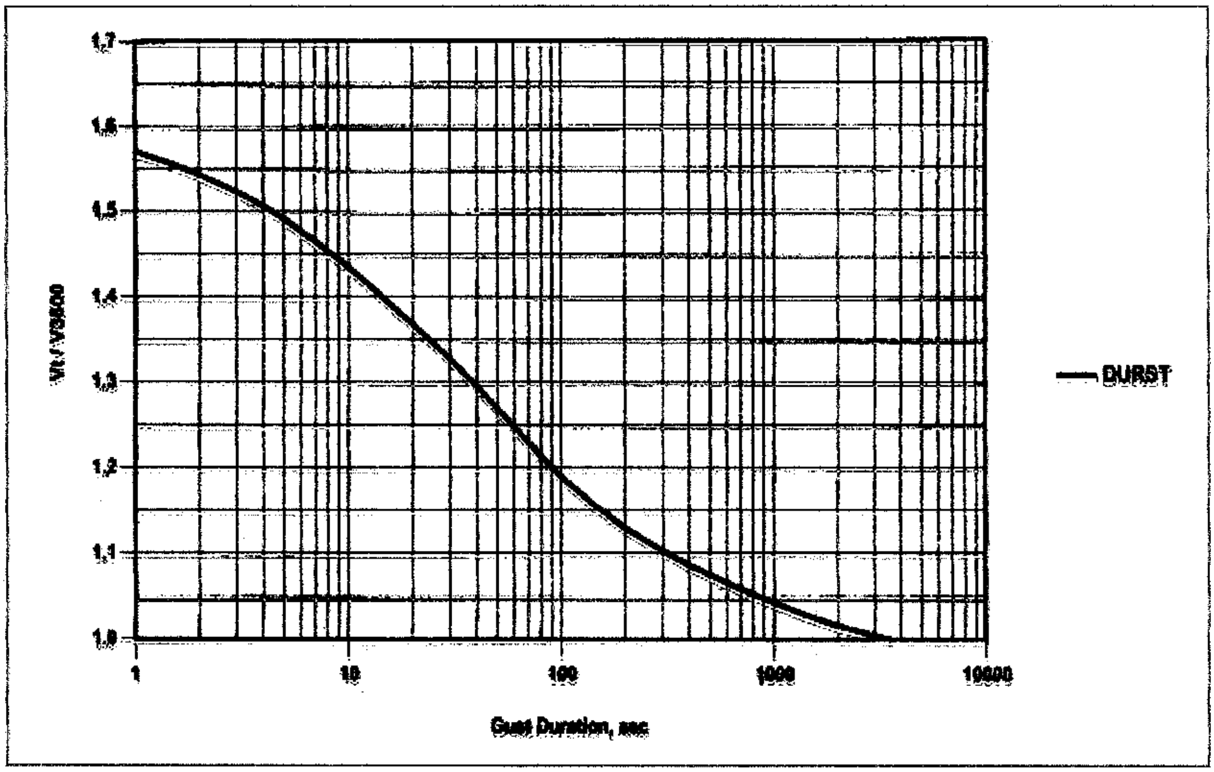


**Figure 2.2: Maximum Wind Speed Average Over ts To Hourly Means Speed**

Figure 2.2 show the durst graph for maximum wind speed average over ts to hourly means speed as provided in ASCE 7-05. This graph is used to convert the gust duration to hourly means speed. From this graph,we can obtain the convertion coefficient that can be used to convert the average wind speed. The x-axis show the gust duration and the y-axis show the coefficient for $V_t/V_{3600}$. Vt is the basic wind speed at 3 second gust duration meanwhile the $V_{3600}$ is the wind speed at hourly means duration.

Convertion Example: To convert 33.5 m/s wind speed at 3 second gust duration to hourly means speed.

Gust Duration = 3 second

Basic Wind Speed = 33.5 m/s (3 second gust duration)

$V_t/V_{3600}$ = 1.52 (from graph)

V3600 = Vt x (1/1.52) = 33.5 x (0.66) = 22.11 m/s

## 2.6 Foundation Design and Type for Transmission Line Tower

Transmission line towers is subjected to torsional force. Foundation design of tower face many serious problem due to various type of soil and many different forces acting on the foundation. The type of loading that control on the foundation design will be based on tower type. For 4 leg steel lattice transmission tower, the controlling design load are vertial uplit,compression and side thrust. Depending on the site condition and the force acting on the tower leg, one of the following types of foundation are normally employed (Subramanian & Vasanthi, 1990) :

- Drilled and/belled shaft
- Pad and chimney
- Footing with undercut
- Auger with reaming
- Grillage
- Special type

Stem and pad foundation are normally used where the soil condition have good bearing capacity and there is no problem with ground water table. Stem and pad foundation can resist compression and moments loads through soil below the mat while uplift loads and overturning are resist by foundation weight plus the earth mass above the mat (Hafiz, 2005). The foundation usually is designed and being optimize for:

i. Tower type (loading)
ii. Geotechnical condition
iii. A foundation type
iv. Function/Performance
v. Economic/Cost

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Research will be starting with a literature review regarding transmission line tower, calculation of load acting on tower structure using different codes of practice and followed by structure modeling analysis using Staad pro software. Details regarding the methodology for each part will be discussed in next section. Figure 3.1 shows the work sequence for this project:

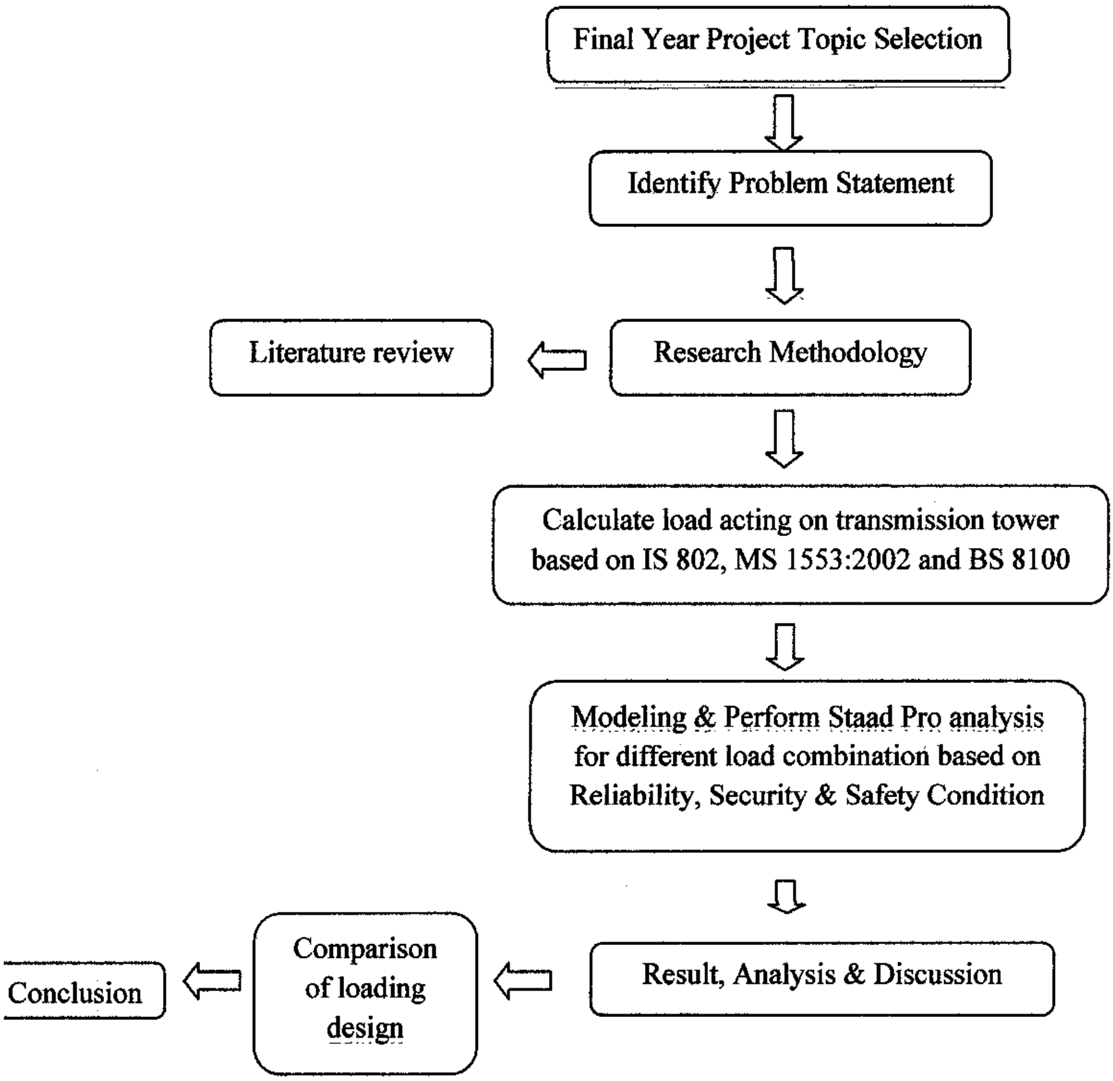


**Figure 3.1: Sequence of Work for Final Year Project "Design of Transmission Line Tower and its Performance**

### 3.2 Literature Review

Literature review is the preliminary stage of research to get overview and some information regarding the chosen topics. The research being conduct based on a few case studies and previous research that had been done by other researcher. Literature review can be done based on a few types of research documents such as journals, articles, text book, conference paper, project paper, internet and many more.

This stage is very important because author will have some idea and some theoretical knowledge regarding transmission line system. Based on literature review, author will focus on the types of transmission line tower used in Malaysia including the geometry, material used, foundation, important components of transmission line and also the failure of transmission line tower. The author also will study the previous research regarding the tower design and the optimization method that can be done on the tower structure. All the literature review will be summarize and compile in Extended Proposal and will be submit to FYP supervisor.

### 3.3 Calculation of load acting on tower based on 3 different code of practice.

In Malaysia, there is no further study regarding the differences between load acting on tower if we use different code. Different code has a different coefficients and equations that being used in tower design. So, by using different code in tower design, the load acting on tower maybe is slightly different. One typical structure of lattice steel (existing tower) structure will be choose. The location of this tower (at Peninsular Malaysia and the geometry will be same in all case. Firstly, author will calculated the load acting on tower body using BS 8110 and complete the design. After that, author will proceed with load calculation using IS 802 and MS 1553:2002 The parameters of the structure will be same for each case. After all the loading on tower structure are obtained, the comparison and analysis will be done. The methodology for the load calculation for tower design shown in Figure 3.2:

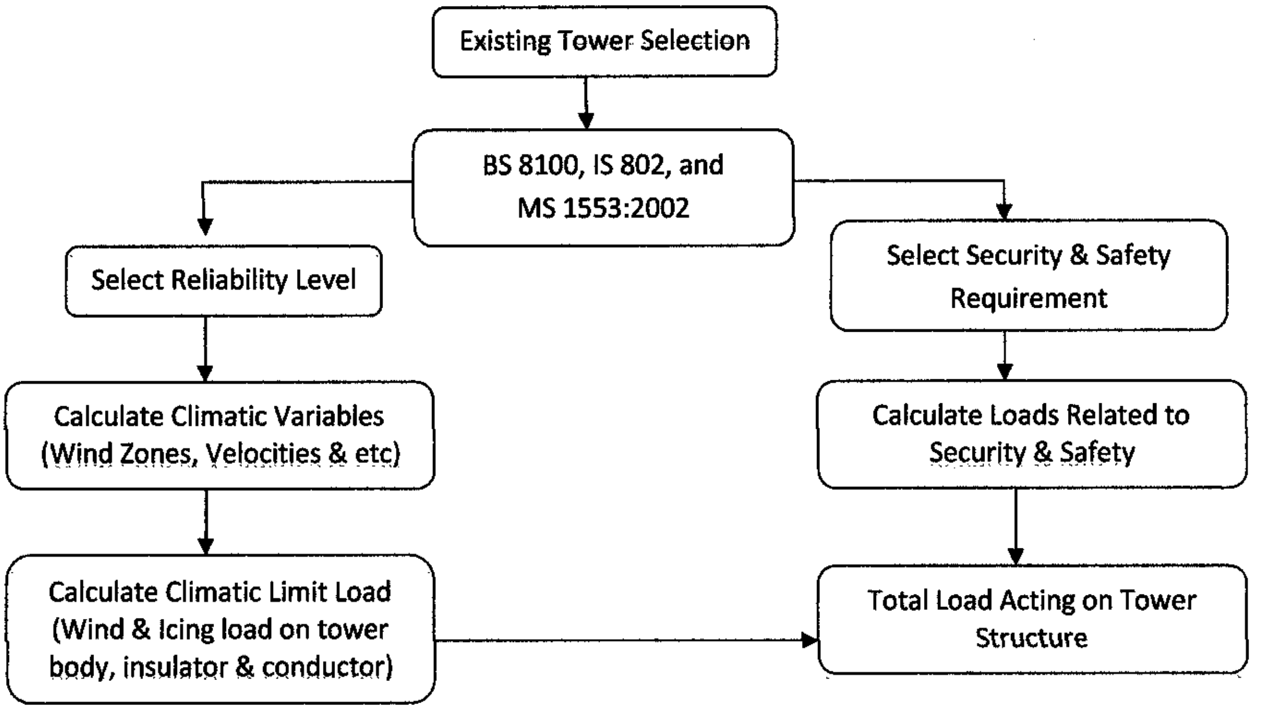


**Figure 3.2: The methodology for the load calculation for tower design**

### 3.4 Staad Pro Model & Analysis

Staad Pro software is one of structural analysis and design software available in market. Using this software, the modeling analysis will be done on one typical transmission line tower which is 275 kV double circuit lattice steel tower located in Peninsular Malaysia. The Staad Pro 2007 software will be used in this research for designing and modeling analysis on structural members of selected tower due to several failure conditions such as loading due to broken wire, earth wire broken and earthquake condition and perform the design optimization. During the modeling analysis, the transverse horizontal load, longitudinal horizontal load and vertical load will be applied separately. The deflection of tower, compression & tension in members will be record and analyze. Using this Staad pro software, we also can analyze the moment due to external load and we also can view forces, stresses, displacement and design result easily. The load combination will be analyze and the results will be compared using the 3 different codes.

### 3.5 Transmission Line Component for Numerical Study

The load using 3 different codes acting on a typical type of lattice steel tower is calculated. The parameters for structural and electrical design parameters for transmission line tower and its components are shown below:

1. Transmission Line Tower Type : Tangent Type
2. Transmission Line Voltage : 275 kV (A/C)
3. Angle of Line Deviation : 0° to 2°
4. Tower Geometry : Square Base Tower
5. Bracing Pattern : Warren Type(Double Web System)
6. Cross Arm : Pointed
7. Tower Height : 33.52 m
8. Tower Width (Base) : 5.88 m
9. Ground Clearance (Min) : 7 m
10. Case Study Area : Perak, Malaysia
11. Basic Wind Speed : 33.5 m/s
12. Conductor
    - Material/Type : ACSR
    - Configuration : Zebra Type
    - Maximum Temperature : 75°
13. Ground Wire
    - Material/Type : Earth Wire
    - Maximum Temperature : 53°
    - No of GW : 1
14. Insulator
    - Material/Type : I String
    - No of Insulator Disk : 14
    - Size : 255 x 145 mm
    - Length : 2.34 m

### 3.6 Design Parameter in Codes of Practices.

#### 3.6.1 BS 8100

| | |
|---|---|
| 1. Tower Classification | : Class A |
| 2. Return Period | : 50 years |
| 3. Terrain Categories | : III (Basic Open Terrain) |
| 4. Basic Wind Speed | : 33.5 m/s (3 second gust) |
| | 22.11 m/s (Hourly mean wind speed) |
| 5. Wind Directional Factor | : 1 (free ice condition) |
| 6. Terrain roughness Coefficient | : 1 |

#### 3.6.2 IS 802

| | |
|---|---|
| 1. Return Period | : 50 years |
| 2. Reliability Level | : 1 |
| 3. Yearly Reliability | : $1\text{-}10^{-3}$ |
| 4. Terrain Categories | : 1 (Exposed Open Terrain) |
| 5. Basic Wind Speed | : 33.5 m/s (3 second gust wind speed) |
| 6. Terrain Roughness Coefficient | : 1.08 |

#### 3.6.3 MS 1553:2002

| | |
|---|---|
| 1. Return Period | : 50 years |
| 2. Structure Category | : II |
| 3. Impotence Factor | : 1.0 |
| 4. Terrain category | : 1 (Exposed Open Terrain) |
| 5. Basic Wind Speed | : 33.5 m/s (3 second gust ) |

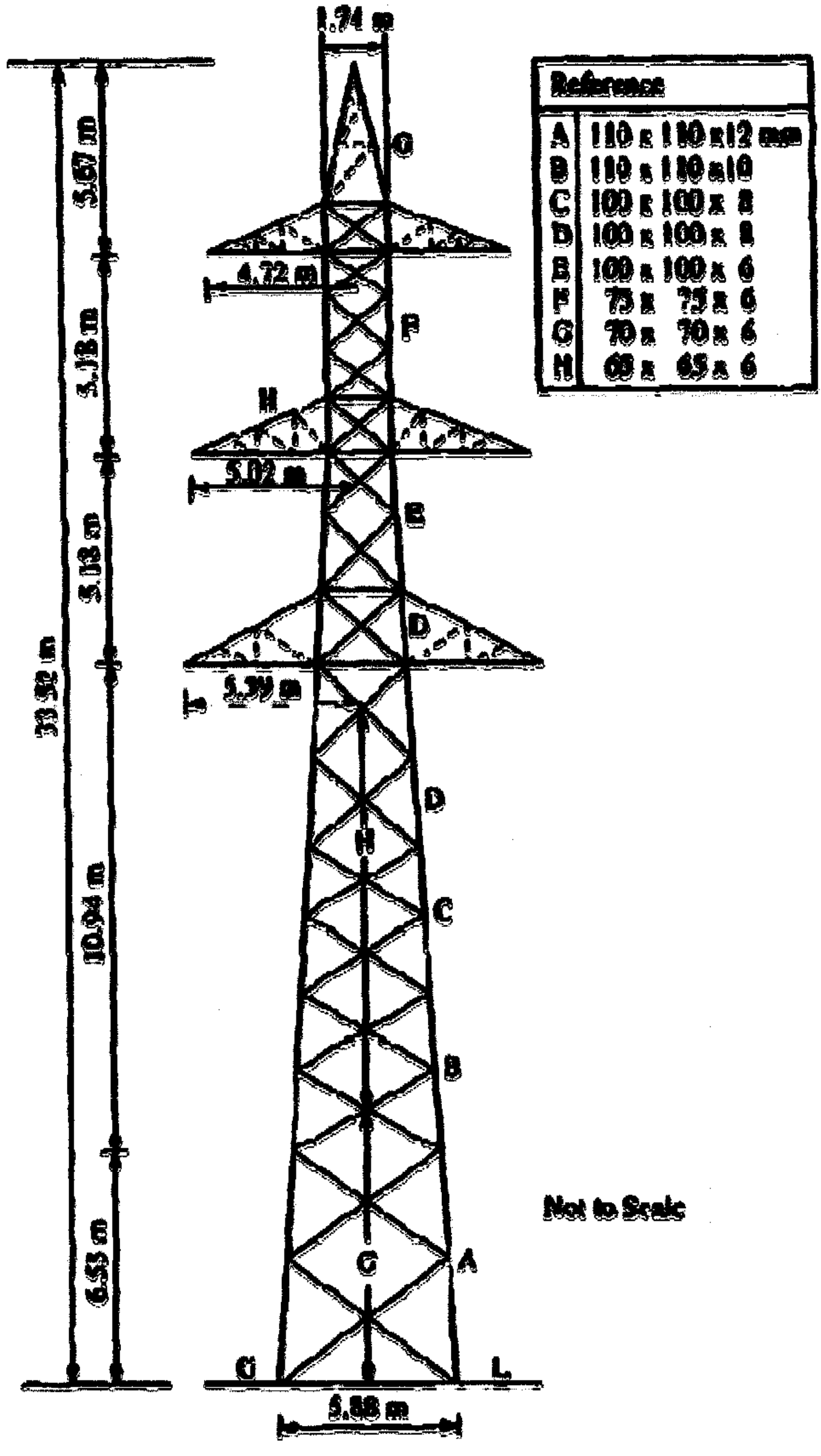


**Figure 3.3: Front view of model for modeling and analysis (Natarajan & Santharkumar, 1995)**

### 3.7 Steps to create Tower Model using Staad Pro 2007.

**[Step 1]:** Select the STAAD.*Pro* icon from the STAAD.Pro 2007 program group.

**[Step 2]**: Create a new project by click the "New Project" under Project Task section.

**[Step 3]**: In the New dialogue box, select structure type as "Space", Specify the File Name and Location, Select Length Unit and Force Unit.

**[Step 4]**: After specifying the input above (Step 3), click on the Next button.

**[Step 5]**: In next new dialogue box, choose Add Beam and click Finished.

**[Step 6]**: Click Edit on Snap Node/Beam dialogue box and linear dialogue box will appear. Set the construction line for X and Y direction.

**[Step 7]**: Close Snap Node/Beam dialogue box.

**[Step 8]**: Insert coordinate for 1 side of tower leg in Nodes dialogue box.

**[Step 9]**: Connect the entire panel in the Beam dialogue box.

**[Step 10]**: Select and Mirror the 1$^{st}$ side of tower leg.
Select all panels→ Menu Option (Geometry) → Mirror → Use Y-Z plane at x=middle base (base length/2)

**[Step 11]**: View the geometry from +z view by clicking on +z view icon.

**[Step 12]**: Connect all bracing.
Menu Option (Geometry)→Add Beam→Add Beam from Point to Point

**[Step 13]**: Select and Mirror this 2$^{nd}$ side of tower leg.

Select all panels→ Menu Option (Geometry) → Mirror → Use X-Y plane at x=middle base (base length/2)

**[Step 14]**: View the tower geometry from +x view by clicking on +x view icon.

**[Step 15]**: Connect all bracing.

Menu Option (Geometry)→Add Beam→Add Beam from Point to Point

**[Step 16]**: Select and Mirror this side.

Select all panels→ Menu Option (Geometry) → Mirror → Use Y-Z plane at x=middle base (base length/2)

**[Step 17]**: The tower ready and can be view in 3D rendering view.

Right Click→3D Rendering

## 3.8 Steps to Perform Analysis on Tower Model using Staad Pro 2007

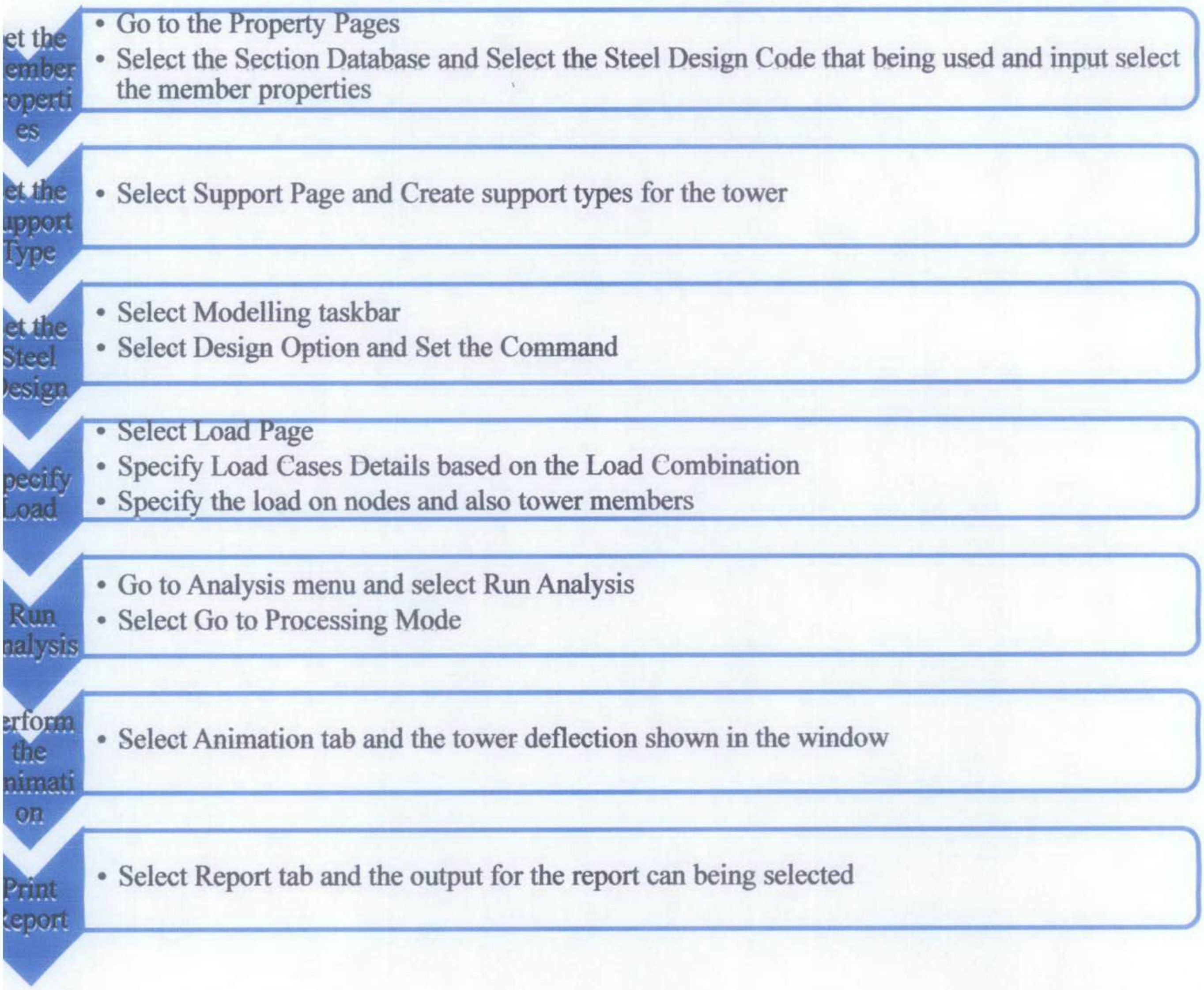


**Figure 3.4: Step to Perform Analysis on Tower Model using Staad Pro 2007**

### 3.9 Gantt Chart and Key Milestone (FYP 1 and FYP 2)

#### i) Final Year Project 1 (May 2011)

| No | Task Name | Week 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Topic Selection | | | | | | | | MID SEM BREAK | | | | | | | |
| 2 | FYP Briefing | | | | | | | | | | | | | | | |
| 3 | Preliminary research work (Literature Review) | | | | | | | | | | | | | | | |
| 4 | Submission of Extended Proposal | | | | | | | | | | | | | | | |
| 5 | Meeting with FYP supervisor | | | | | | | | | | | | | | | |
| 6 | Proposal Defense | | | | | | | | | | | | | | | |
| 7 | Preliminary Staad Pro modeling & Load Calculation | | | | | | | | | | | | | | | |
| 8 | Submission of Interim Draft Report | | | | | | | | | | | | | | | |
| 9 | Submission of Interim Report | | | | | | | | | | | | | | | |

**Figure 3.5: Gantt Chart FYP 1**

#### ii) Final Year Project 2 (September 2011)

| No | Task Name | Week 1 | 2 | 3 | 4 | 5 | 6 | 7 | | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Staad Pro Modeling & Load Calculation | | | | | | | | MID SEM BREAK | | | | | | | | |
| 2 | Submission Progress Report | | | | | | | | | | | | | | | | |
| 3 | Pre - EDX | | | | | | | | | | | | | | | | |
| 4 | Submission of Draft Report | | | | | | | | | | | | | | | | |
| 5 | Submission of Dissertation (Soft Bound) | | | | | | | | | | | | | | | | |
| 6 | Submission of Technical Paper | | | | | | | | | | | | | | | | |
| 7 | Oral Presentation | | | | | | | | | | | | | | | | |
| 8 | Submission of Project Dissertation (Hard Bound) | | | | | | | | | | | | | | | | |

**Figure 3.6: Gantt Chart FYP 2**

- Process

- Key Milestone

### 3.10 Tools Required (Software)

In this project, the tower modeling analysis can be performed using Staad Pro software. This software is a comprehensive and integrated finite element analysis package. This software has different code of practice including international code. Using this Staad Pro software, we can analyze any structure exposed to static loading, a dynamic response, soil structure response, wind, earthquake and moving loads. This software can provide general purpose structural analysis and integrates steel/concrete/timber. The tower also can be modeled in animation mode to see the tower deflection. Staad Pro also can do many types of engineering analysis mode such as Perform Analysis Delta Analysis, Perform Push Over Analysis, and Perform Buckling Analysis. However, for this thesis, author only will use Perform Analysis Mode to analyze the tower under specified load combination.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Tower Model using Staad Pro 2007

This is the example of 275 kV double circuit lattice steel tower with square base. The height is 33.52m and the tower base width is 5.88m.The tower model can being generated either in 2D view or 3D view. Below are the results:

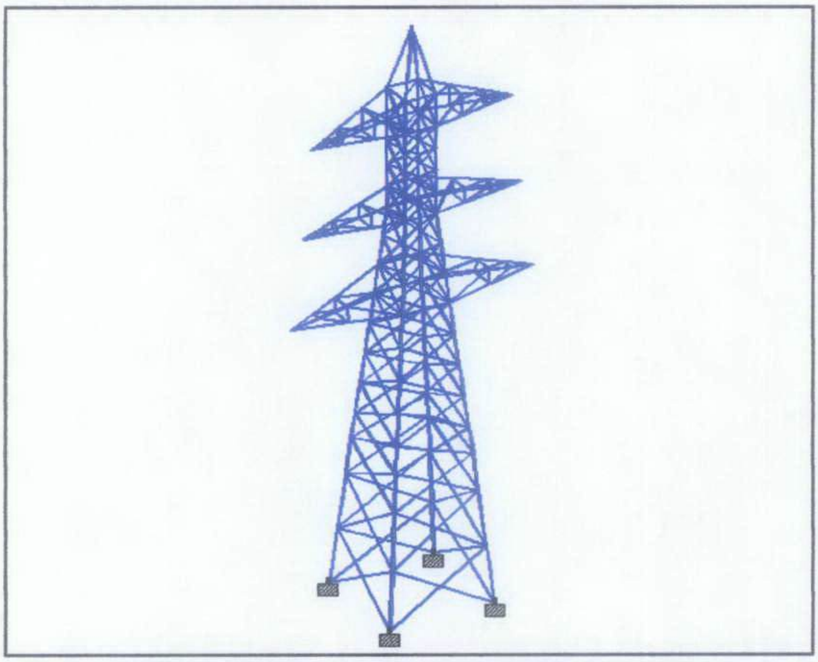

**Figure 4.1: 3D view (Tower With Cross Arm)**

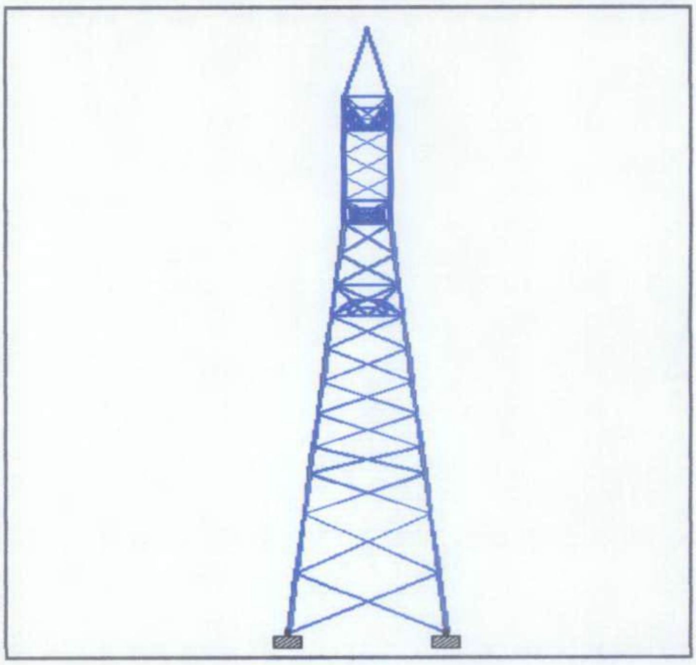

**Figure 4.2: 2D view (X Direction)**

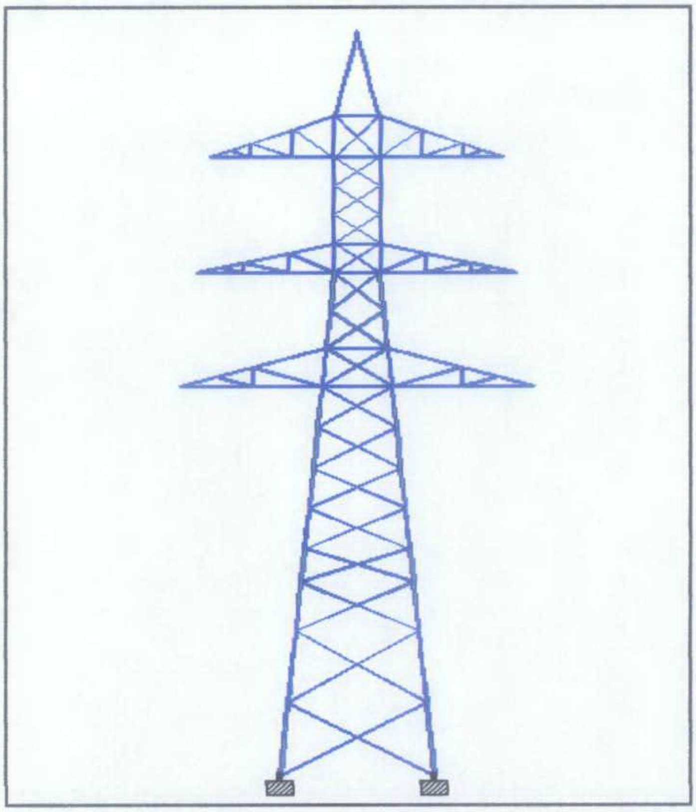

**Figure 4.3: 2D view (Z Direction)**

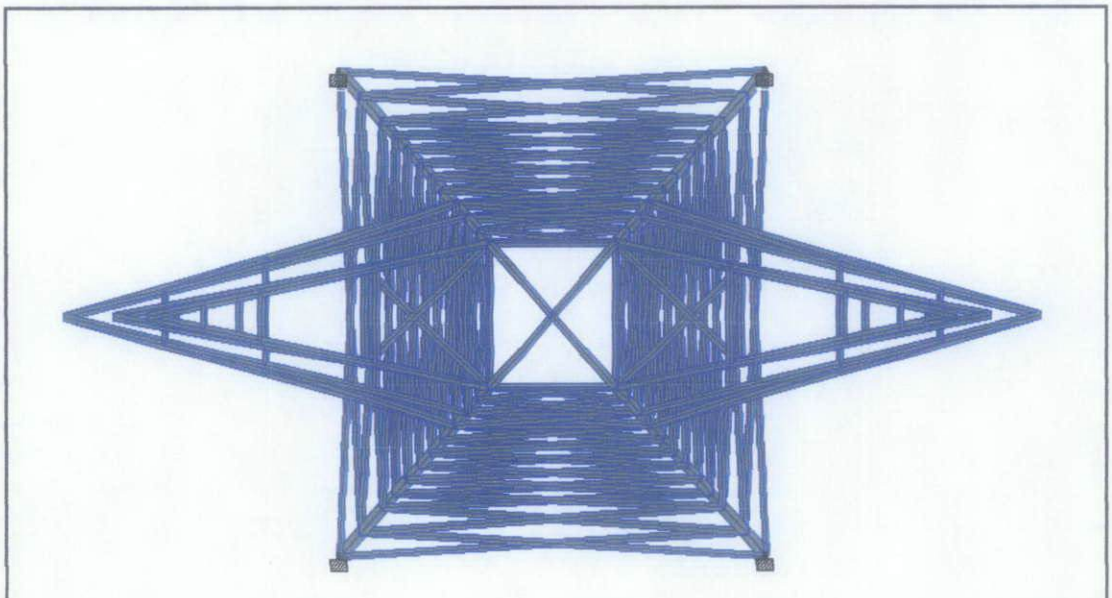

**Figure 4.4: 2D view (Y Direction)**

## 4.2 Calculation of Load Acting on Tower Body and Its Components

The tower is located in Perak (Peninsular Malaysia). The 275 kV double circuit tower have height 33.52 m and square base width (5.88m x 5.88). The tower is suspension type.

The performance requirement and meteorological parameters for BS 8100-1:1996 for the load computation are:

| Performance Requirement / Meteorological Parameters | Value/Category | Description |
|---|---|---|
| Partial Safety Factor, $\delta v$ | 1 | Figure 2.1 (BS 8100-1:1986) |
| Wind Directional Factor, Kd | 1 | Clause 3.1.3(BS 8100-1:1986) |
| Terrain Categories | III (Basic Open Terrain) | Table 3.1( BS 8100-1:1986) |
| Terrain Roughness Factor, $K_R$ | 1 | Table 3.1( BS 8100-1:1986) |
| Power Law Index of Vibration of Wind Speed With Height, $\alpha$ | 0.165 | Table 3.1( BS 8100-1:1986) |
| Effective Height, he | 0 | Table 3.1( BS 8100-1:1986) |
| Air Density | 1.22 kg/m$^3$ | - |
| Overall Normal Drag Coefficient, $C_N$ | 3.4 | Figure 4.3 (BS 8100-1:1986) |
| Wind Incidence Coefficient, $K_\Theta$ | 1 | Figure 4.2 (BS 8100-1:1986) |

**Table 4.1: Performance and Requirement Parameters (BS 8100)**

The performance requirement and meteorological parameters for IS 802(Part 1/Sec 1):1995 for the load computation are:

| Performance Requirement / Meteorological Parameters | Value/Category | Description |
|---|---|---|
| Basic Wind Speed | 33.5 m/s | Peninsular Malaysia (Perak) |
| Reliability Level | 1 | Table 1 (IS 802 Part 1/Sec 1 : 1995) |
| Return Period | 50 years | Table 1 (IS 802 Part 1/Sec 1 : 1995) |
| Ko | 1.375 | Clause 8.2 (IS 802 Part 1/Sec 1 : 1995) |
| Risk Coefficient, $K_1$ | 1.00 | Table 2 (IS 802 Part 1/Sec 1 : 1995) |
| Terrain Category | 1 | Clause 8.3.2.1 (IS 802 Part 1/Sec 1 : 1995) |
| Terrain Roughness Coefficient,$K_2$ | 1.08 | Table 3 (IS 802 Part 1/Sec 1 : 1995) |
| Air Density | 1.22 kg/m$^3$ | - |

**Table 4.2: Performance and Requirement Parameters (IS 802)**

| Performance Requirement / Meteorological Parameters | Value/Category | Description |
|---|---|---|
| Basic Wind Speed | 33.5 m/s | Peninsular Malaysia (Perak) |
| Return Period | 50 years | (table 3.1) |
| Importance Factor | 1 | (table 3.2) |
| Shilding Multiplier | 1 | (table 4.3) |
| Hill Shape Multiplier | 1 | (clause 4.4) |
| Terrain Category | 1 | (clause 4.2.1) |
| Air Density | 1.225 kg/m$^3$ | (clause 2.4.1) - |

**Table 4.3: Performance and Requirement Parameters (MS 1553)**

### 4.2.1 Wind Speed and Wind Profile

| Panel Number | Tower height, z (m) | Design Wind Speed (m/s) (BS 8100) | Design Wind Speed (m/s) (MS 1553) | Design Wind Speed (m/s) (IS 802) |
|---|---|---|---|---|
| 1 | **31.63** | 26.74 | 36.88 | 28.38 |
| 2 | **28.795** | 26.33 | 36.67 | 28.38 |
| 3 | **27.2025** | 26.08 | 36.53 | 28.38 |
| 4 | **25.9075** | 25.87 | 36.41 | 28.38 |
| 5 | **24.6125** | 25.65 | 36.29 | 28.38 |
| 6 | **23.3175** | 25.42 | 36.18 | 28.38 |
| 7 | **21.8075** | 25.15 | 36.04 | 28.38 |
| 8 | **20.0805** | 24.81 | 35.88 | 28.38 |
| 9 | **18.3535** | 24.44 | 35.58 | 28.38 |
| 10 | **16.5765** | 24.03 | 35.26 | 28.38 |
| 11 | **14.7535** | 23.58 | 34.91 | 28.38 |
| 12 | **12.9305** | 23.07 | 34.47 | 28.38 |
| 13 | **11.1075** | 22.50 | 34.04 | 28.38 |
| 14 | **9.2845** | 21.32 | 33.47 | 28.38 |
| 15 | **7.4615** | 19.30 | 32.70 | 28.38 |
| 16 | **4.9125** | 16.49 | 31.58 | 28.38 |
| 17 | **1.6375** | 12.87 | 29.85 | 28.38 |

**Table 4.4: Design Wind Speed based on BS 8100, MS 1553 and IS 802.**

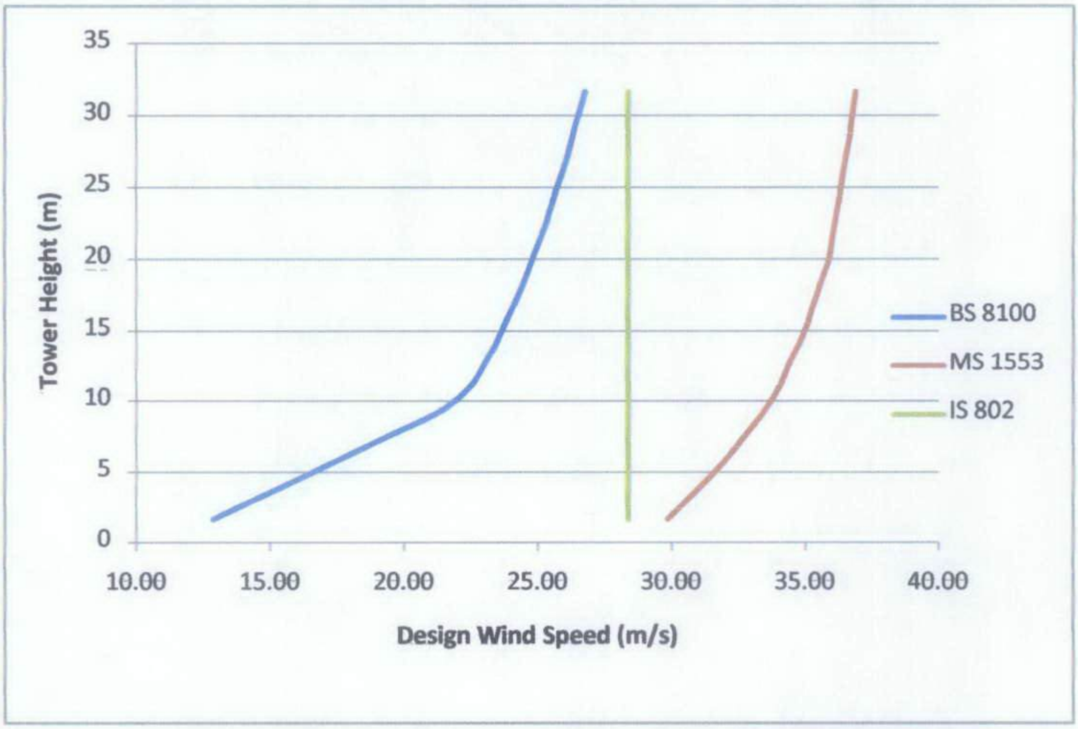


**Figure 4.5: Height from Ground (m) vs Design Wind Speed (m/s)**

### 4.2.2 Design Wind Speed Percentage Differences

| Panel Number | Design Wind Speed (m/s) BS 8100 | Design Wind Speed (m/s) IS 802 | Differences (%) |
|---|---|---|---|
| 1 | 26.74 | 28.38 | 5.8 |
| 2 | 26.33 | 28.38 | 7.2 |
| 3 | 26.08 | 28.38 | 8.1 |
| 4 | 25.87 | 28.38 | 8.8 |
| 5 | 25.65 | 28.38 | 9.6 |
| 6 | 25.42 | 28.38 | 10.4 |
| 7 | 25.15 | 28.38 | 11.4 |
| 8 | 24.81 | 28.38 | 12.6 |
| 9 | 24.44 | 28.38 | 13.9 |
| 10 | 24.03 | 28.38 | 15.3 |
| 11 | 23.58 | 28.38 | 16.9 |
| 12 | 23.07 | 28.38 | 18.7 |
| 13 | 22.50 | 28.38 | 20.7 |
| 14 | 21.32 | 28.38 | 24.9 |
| 15 | 19.30 | 28.38 | 32.0 |
| 16 | 16.49 | 28.38 | 41.9 |
| 17 | 12.87 | 28.38 | 54.7 |

**Table 4.5: Percentage differences between Design Wind Speed for BS 8100 and IS 802**

| Panel Number | Design Wind Speed (m/s) BS 8100 | Design Wind Speed (m/s) MS 1553 | Differences (%) |
|---|---|---|---|
| 1 | 26.74 | 36.88 | 27.5 |
| 2 | 26.33 | 36.67 | 28.2 |
| 3 | 26.08 | 36.53 | 28.6 |
| 4 | 25.87 | 36.41 | 29.0 |
| 5 | 25.65 | 36.29 | 29.3 |
| 6 | 25.42 | 36.18 | 29.7 |
| 7 | 25.15 | 36.04 | 30.2 |
| 8 | 24.81 | 35.88 | 30.9 |
| 9 | 24.44 | 35.58 | 31.3 |
| 10 | 24.03 | 35.26 | 31.8 |
| 11 | 23.58 | 34.91 | 32.5 |
| 12 | 23.07 | 34.47 | 33.1 |
| 13 | 22.50 | 34.04 | 33.9 |
| 14 | 21.32 | 33.47 | 36.3 |
| 15 | 19.30 | 32.70 | 41.0 |
| 16 | 16.49 | 31.58 | 47.8 |
| 17 | 12.87 | 29.85 | 56.9 |

**Table 4.6: Percentage differences between Design Wind Speed for BS 8100 and MS 1553**

| Panel Number | Design Wind Speed (m/s) MS 1553 | Design Wind Speed (m/s) IS 802 | Differences (%) |
|---|---|---|---|
| 1 | 36.88 | 28.38 | 23.1 |
| 2 | 36.67 | 28.38 | 22.6 |
| 3 | 36.53 | 28.38 | 22.3 |
| 4 | 36.41 | 28.38 | 22.1 |
| 5 | 36.29 | 28.38 | 21.8 |
| 6 | 36.18 | 28.38 | 21.6 |
| 7 | 36.04 | 28.38 | 21.3 |
| 8 | 35.88 | 28.38 | 20.9 |
| 9 | 35.58 | 28.38 | 20.2 |
| 10 | 35.26 | 28.38 | 19.5 |
| 11 | 34.91 | 28.38 | 18.7 |
| 12 | 34.47 | 28.38 | 17.7 |
| 13 | 34.04 | 28.38 | 16.6 |
| 14 | 33.47 | 28.38 | 15.2 |
| 15 | 32.70 | 28.38 | 13.2 |
| 16 | 31.58 | 28.38 | 10.1 |
| 17 | 29.85 | 28.38 | 4.9 |

**Table 4.7: Percentage differences between Design Wind Speed for MS 1553 and IS 802**

**Discussion:**

1) The wind profile generated from design wind speed at height using the 3 codes of standards is different from each other. For IS 802, the design wind speed is same for all height because in the design codes because no factor is provided for different heights.

2) The wind profile for BS 8100 is quite linear and has lower value compared to the IS 802 and MS 1553. This is because for BS 8100, the 3 second gust basic wind speed which is 33.5 m/s is converted to hourly mean wind speed by multiplying the 33.5 m/s value with a factor of 0.66. This conversion will cause the basic wind speed for BS 8100 becomes smaller compared to the IS 802 and MS 1553.

3) For MS 1553, this code is using average 3 second gust wind speed as the basic wind speed. So there is no conversion needed to convert the basic wind speed (33.5 m/s) because it is already in average 3 second gust wind speed.

4)For IS 802, this code is using average wind speed during 10 minutes and the basic wind speed is converted to meteorological reference wind speed by dividing the basic wind speed(33.5 m/s) with factor of 1.375.

5) The average wind speed during the period of 3 second gust should be higher compared to the period of 10 minutes and hourly duration because it has shorter time so the average wind speed will be higher. Shorter the duration of wind speed, the higher average wind speed.

6) For BS 8100 and MS 1553, the design wind speed increases slowly from the bottom to the top of tower. The design wind speed pattern for BS 8100 and MS 1553 is almost same.

7) The percentage difference between design wind speeds for MS 1553 with BS 8100 is the highest among the others.

### 4.2.3 Wind Load Acting On Tower Panel

| Panel No | Tower height, z (m) | Wind Load BS 8100 (kN) | Wind Load IS 802 (kN) | Wind Load MS 1553 (kN) |
|---|---|---|---|---|
| 1 | **31.63** | 2.3669 | 1.5049 | 1.6343 |
| 2 | **28.795** | 2.7397 | 1.7072 | 2.1882 |
| 3 | **27.2025** | 2.0897 | 1.3837 | 1.6739 |
| 4 | **25.9075** | 1.6928 | 1.1015 | 1.4252 |
| 5 | **24.6125** | 1.6771 | 1.0933 | 1.4138 |
| 6 | **23.3175** | 2.1608 | 1.3115 | 1.7577 |
| 7 | **21.8075** | 2.5505 | 1.7915 | 2.2379 |
| 8 | **20.0805** | 2.3732 | 1.8458 | 2.0988 |
| 9 | **18.3535** | 2.7745 | 1.9819 | 2.5417 |
| 10 | **16.5765** | 3.0315 | 2.4730 | 2.7750 |
| 11 | **14.7535** | 2.6514 | 2.1058 | 2.6365 |
| 12 | **12.9305** | 2.6818 | 2.1534 | 2.7167 |
| 13 | **11.1075** | 2.6457 | 2.2129 | 2.7522 |
| 14 | **9.2845** | 2.4343 | 2.1460 | 2.7035 |
| 15 | **7.4615** | 2.4166 | 2.8182 | 3.1536 |
| 16 | **4.9125** | 2.5159 | 3.7114 | 4.2571 |
| 17 | **1.6375** | 1.6115 | 4.5502 | 3.9096 |

**Table 4.8: Wind Load acting on tower panel based on BS 8100, IS 802 and MS 1553**

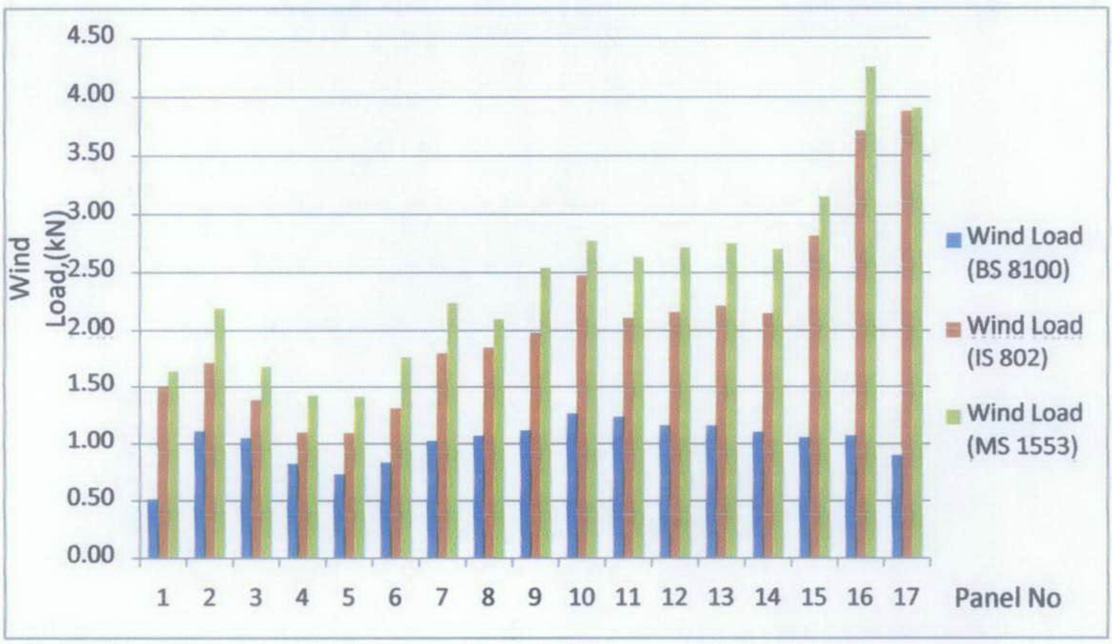


**Figure 4.6: Wind Load Acting on Panel based on BS 8100,IS 802 and MS 1553**

| Design Code | BS 8100 | IS 802 | MS 1553 |
|---|---|---|---|
| Total Wind Load on Tower Body (kN) | 17.2533 | 35.2231 | 41.8757 |

**Table 4.9: Total Wind Load acting on tower panel based on BS 8100, IS 802 and MS 1553**

**Discussion:**

1) Based on Figure 4.6, we can observe that wind load acting on panel for MS 1553 higher than IS 802 and BS 8100. This is because the design wind speed for MS 1553 is higher than IS 802 and BS 8100. Higher design will speed will cause higher wind load acting on tower body. The wind load also will affect the tower deflection.

### 4.2.4 Wind Load Acting On Conductor & Ground Wire

| Code of Practices | BS 8100 | MS 1553 | IS 802 |
|---|---|---|---|
| Wind Load on Conductor (kN) | 4.78 | 13.06 | 10.49 |
| Wind Load on Ground Wire (kN) | 1.27 | 6.01 | 4.95 |

**Table 4.10: Wind load acting on Conductor and Ground Wire based on BS 8100, IS 802 and MS 1553**

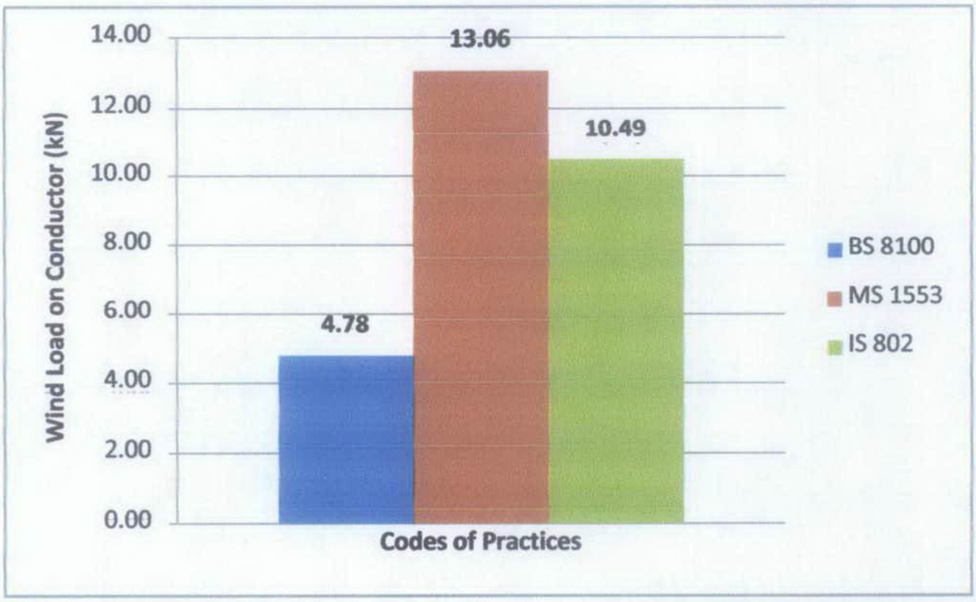


**Figure 4.7: Wind load acting on Conductor based on BS 8100,IS 802 and MS 1553**

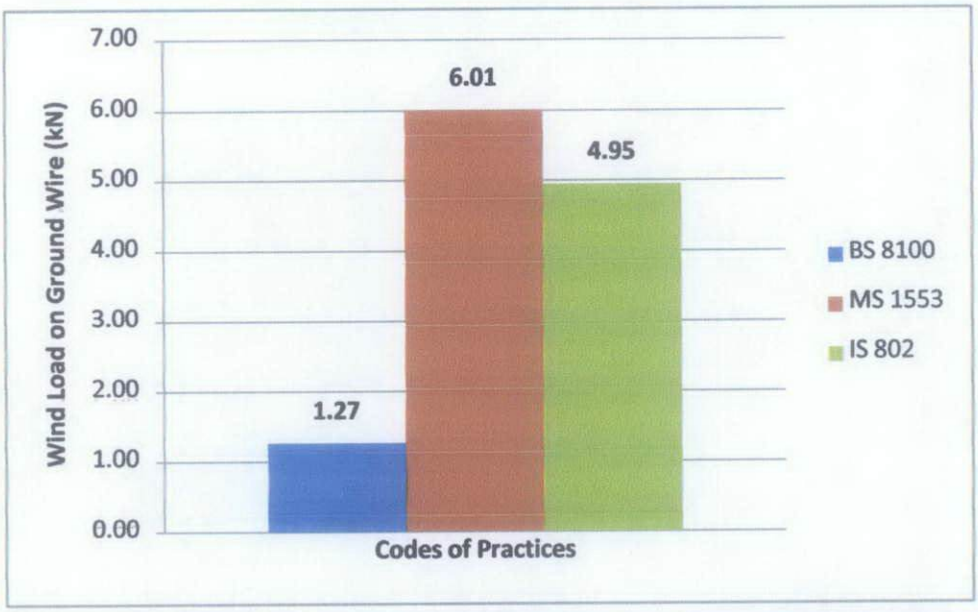


**Figure 4.8: Wind load acting on Ground Wire based on BS 8100,IS 802 and MS 1553**

**Discussion:**

1) Based on Figure 4.7 & Figure 4.8, we can observe that wind load acting on conductor and ground wire for MS 1553 is higher than IS 802 and BS 8100. This is because the design wind pressure for MS 1553 is higher than IS 802 and BS 8100. Higher design will pressure will cause higher wind load acting on conductor and ground wire along the transmission line system.

### 4.2.5 Gust Response Factor

| Panel No | Tower height, z (m) | Gust Response Factor BS 8100 | Gust Response Factor IS 802 | Gust Response Factor MS 1553 |
|---|---|---|---|---|
| 1 | **31.63** | 1.4514 | 1.9780 | 1.20 |
| 2 | **28.795** | 1.4138 | 1.9467 | 1.35 |
| 3 | **27.2025** | 1.3943 | 1.9292 | 1.35 |
| 4 | **25.9075** | 1.3792 | 1.9150 | 1.35 |
| 5 | **24.6125** | 1.3648 | 1.9007 | 1.34 |
| 6 | **23.3175** | 1.3517 | 1.8865 | 1.34 |
| 7 | **21.8075** | 1.3450 | 1.8699 | 1.34 |
| 8 | **20.0805** | 1.3344 | 1.8509 | 1.34 |
| 9 | **18.3535** | 1.3177 | 1.8253 | 1.33 |
| 10 | **16.5765** | 1.3170 | 1.7986 | 1.33 |
| 11 | **14.7535** | 1.3163 | 1.7713 | 1.32 |
| 12 | **12.9305** | 1.2882 | 1.7440 | 1.32 |
| 13 | **11.1075** | 1.2881 | 1.7166 | 1.31 |
| 14 | **9.2845** | 1.2748 | 1.7000 | 1.30 |
| 15 | **7.4615** | 1.2626 | 1.7000 | 1.29 |
| 16 | **4.9125** | 1.2664 | 1.7000 | 1.28 |
| 17 | **1.6375** | 1.2550 | 1.7000 | 1.26 |

**Table 4.11: Gust Response Factor for each tower panel based on BS 8100, IS 802 and MS 1553**

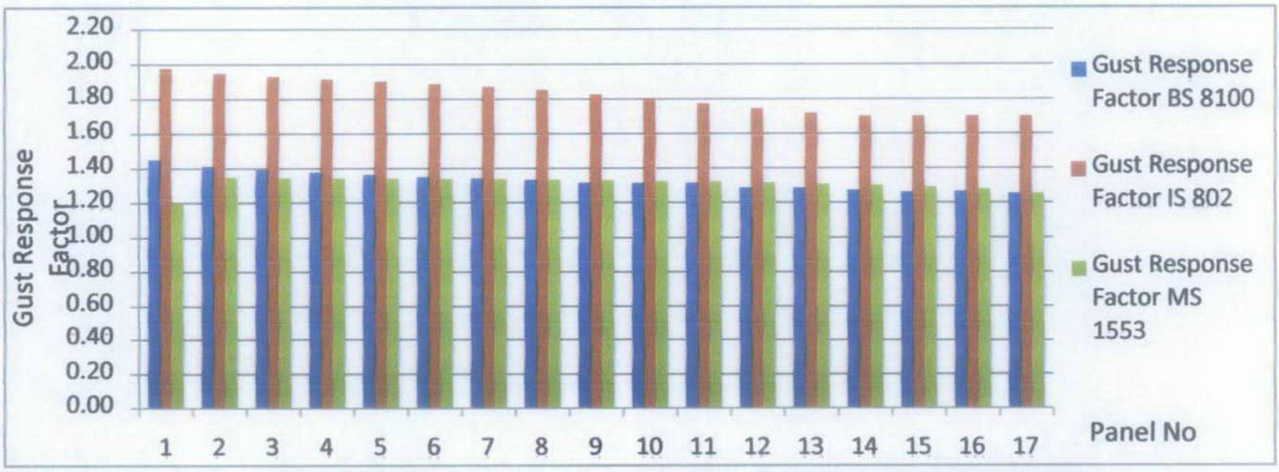


**Figure 4.9: Gust Response Factor for BS 8100,IS802 and MS 1553**

**Discussion:**

1) Based on Figure 4.9, we can observe that IS 802 have greater Gust Response Factor compared to BS 8100 and MS 1553. The reason is IS 802 standard is based on Indian region that have extreme meteorological condition compared to BS 8100(United Kingdom) and MS 1553(Malaysia).

### 4.3 Sag Tension

#### 4.3.1 Sag Tension for Conductor

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 3936 | 4351 | 3333 | 4714 | 5481 | 2793 |
| Sag, S (m) | 8.24 | 7.45 | 9.73 | 6.88 | 5.92 | 11.61 |

**Table 4.12: Sag Tension for conductor based on IS 802**

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 3936 | 7653 | 3333 | 5240 | 6117 | 2794 |
| Sag, S (m) | 8.24 | 4.24 | 9.73 | 6.19 | 5.30 | 11.60 |

**Table 4.13: Sag Tension for conductor based on MS 1553**

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 3948 | 3873 | 3260 | 3381 | 3495 | 2791 |
| Sag, S (m) | 8.21 | 8.37 | 9.95 | 9.59 | 9.28 | 11.62 |

**Table 4.14: Sag Tension for conductor based on BS 8100**

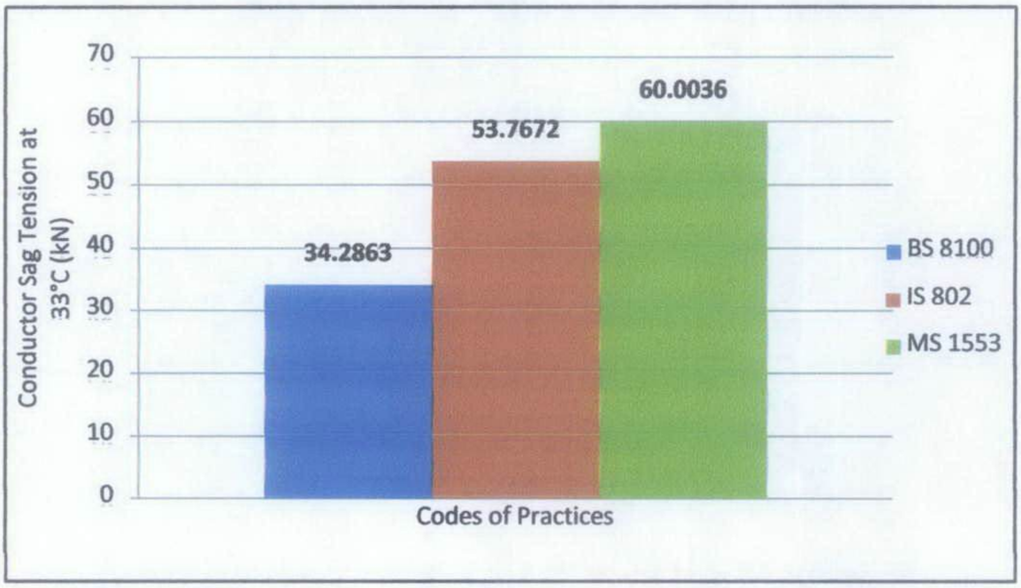


**Figure 4.10: Conductor Sag Tension at 33 °C**

### 4.3.2 Sag Tension for Ground Wire

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 1486 | 1670 | 1324 | 1932 | 2225 | 1167 |
| Sag, S (m) | 7.84 | 6.98 | 8.80 | 6.04 | 5.24 | 9.99 |

**Table 4.15: Sag Tension for ground wire based on IS 802**

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 1486 | 2795 | 1324 | 2128 | 2495 | 1167 |
| Sag, S (m) | 7.84 | 4.17 | 8.80 | 5.48 | 4.67 | 9.99 |

**Table 4.16: Sag Tension for ground wire based on MS 1553**

| Parameters | Value | | | | | |
|---|---|---|---|---|---|---|
| Temperature Variation (°C) | 0 | | 33 | | | 75 |
| Wind Variation (%) | 0 | 0.36 | 0 | 0.75 | 1 | 0 |
| Tension (kg) | 1486 | 1493 | 1324 | 1352 | 1371 | 1167 |
| Sag, S (m) | 7.84 | 7.81 | 8.80 | 8.63 | 8.50 | 9.99 |

**Table 4.17: Sag Tension for ground wire based on BS 8100**

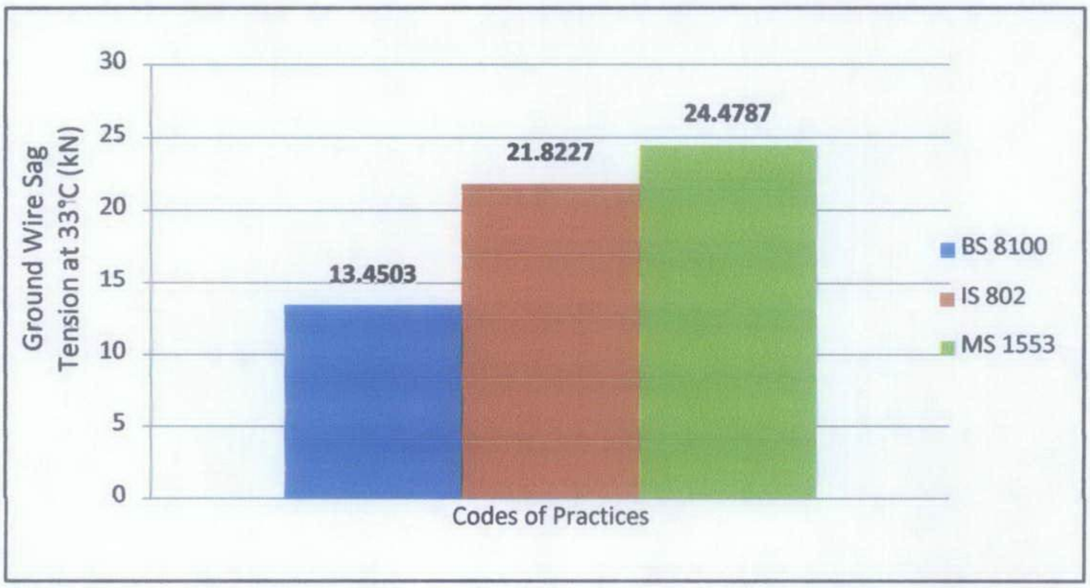


**Figure 4.11: Ground Wire Sag Tension at 33 °C**

**Discussion:**

1) The Sag Tension calculation for conductor and ground wire has been calculated using the Parabolic Equation for different combination of temperature and at different wind variation for BS 8100, IS 802 and MS 1553.

2) Generally, MS 1553 produced more sag tension on conductor and ground wire due to larger design wind pressure compared to BS 8100 and IS 802. Sag tension on conductor and ground wire are used to calculate the load acting on tower body based on Reliability, Security and Safety condition.

## 4.4 Loading Combination Based on Reliability, Security and Safety Condition

Loading combinations for Reliability, Security and Safety condition are calculated using BS 8100, IS 802 and MS 1553. Tower is a space trusses, the loading are synchronized as the point loading of tip of peak and at the six tips of the cross arms. The loading trees consist of:

1. Reliability Condition
    - Normal Condition
2. Security Condition
    - Normal Condition
    - Ground Wire Broken Condition
    - Top Conductor Broken Condition (Left Arm)
    - Middle Conductor Broken Condition (Left Arm)
    - Bottom Conductor Broken Condition (Left Arm)
3. Safety Condition
    - Normal Condition
    - Ground Wire Broken Condition
    - Top Conductor Broken Condition (Left Arm)
    - Middle Conductor Broken Condition (Left Arm)
    - Bottom Conductor Broken Condition (Left Arm)

### 4.4.1 Reliability Condition

#### 4.4.1.1 Tree Diagram for BS 8100

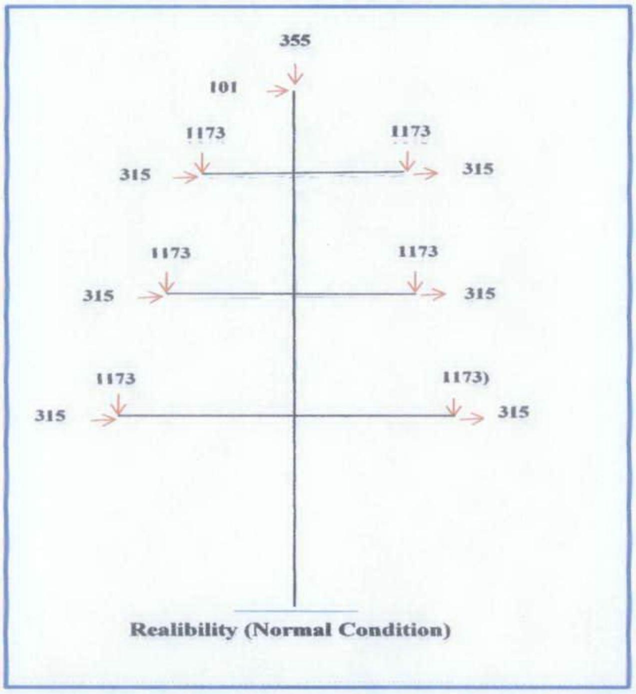


**Figure 4.12: Reliability (Normal Condition) – BS 8100**

#### 4.4.1.2 Tree Diagram for IS 802

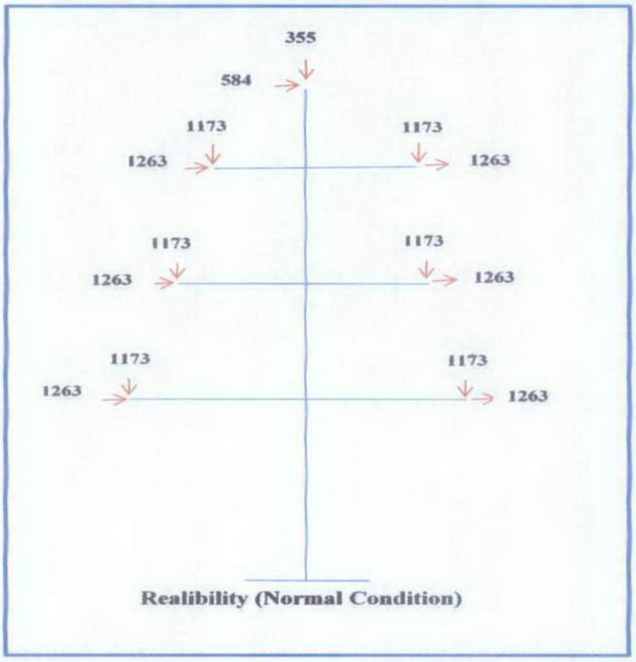


**Figure 4.13: Reliability (Normal Condition) – IS 802**

### 4.4.1.3 Tree Diagram for MS 1553

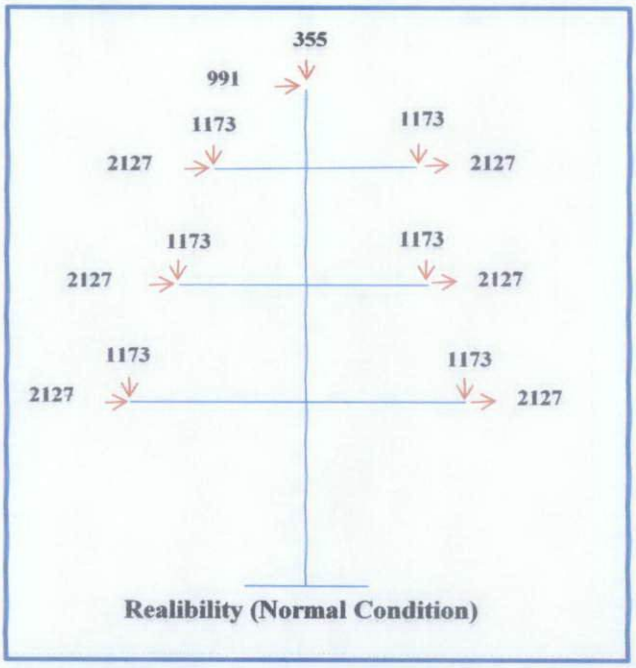


**Figure 4.14: Reliability (Normal Condition) – MS 1553**

**Note:**

**1) GW – Ground Wire**

**2) TC – Top Conductor**

**3) MC – Middle Conductor**

**4) BC – Bottom Conductor**

### 4.4.2 Security Condition

#### 4.4.2.1 Tree Diagram for BS 8100

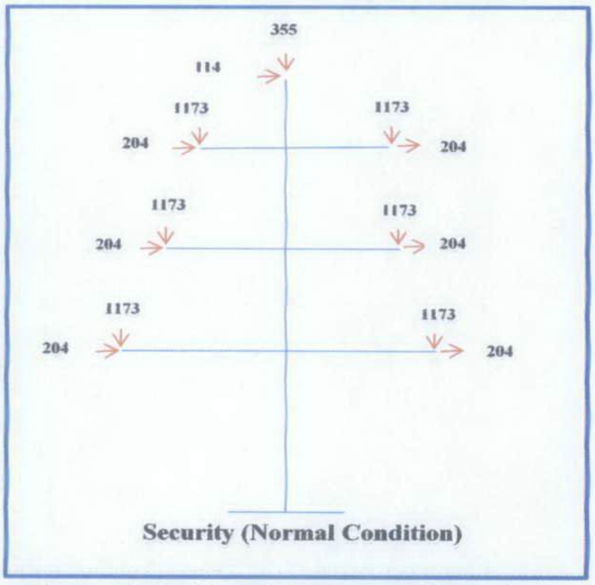


**Figure 4.15: Security (Normal Condition) BS 8100**

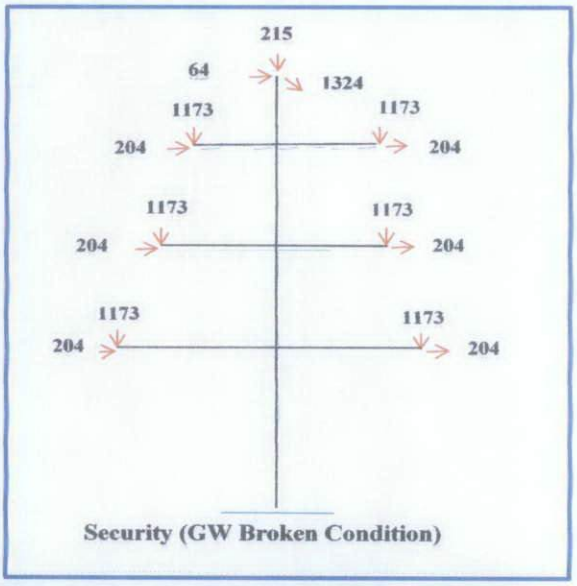


**Figure 4.16: Security (GW Broken Condition) BS 8100**

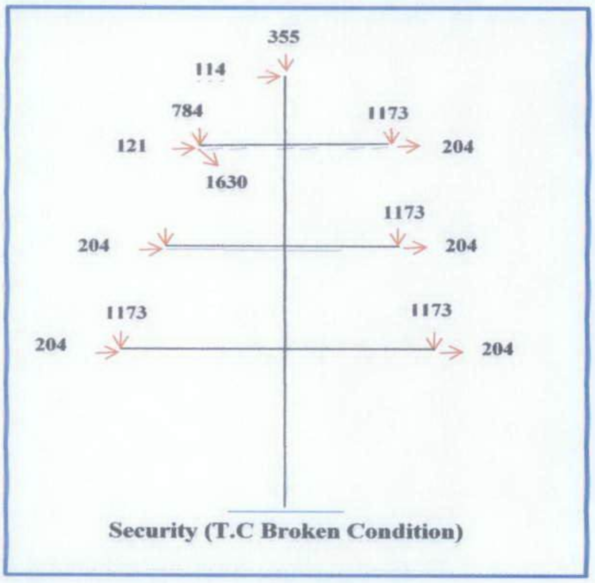


**Figure 4.17: Security (TC Broken Condition) BS 8100**

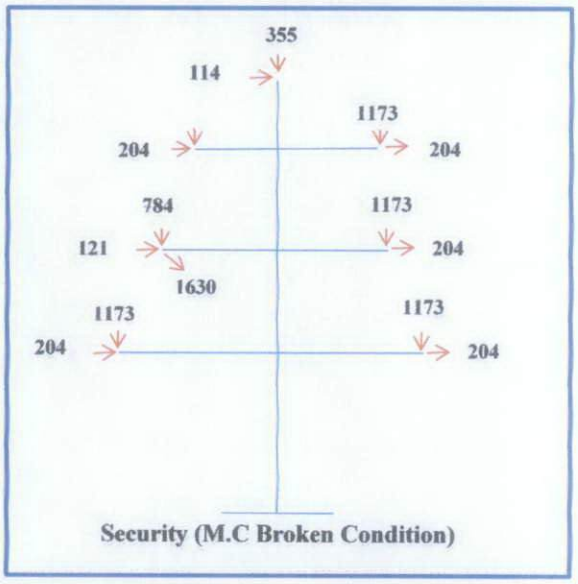


**Figure 4.18: Security (MC Broken Condition) BS 8100**

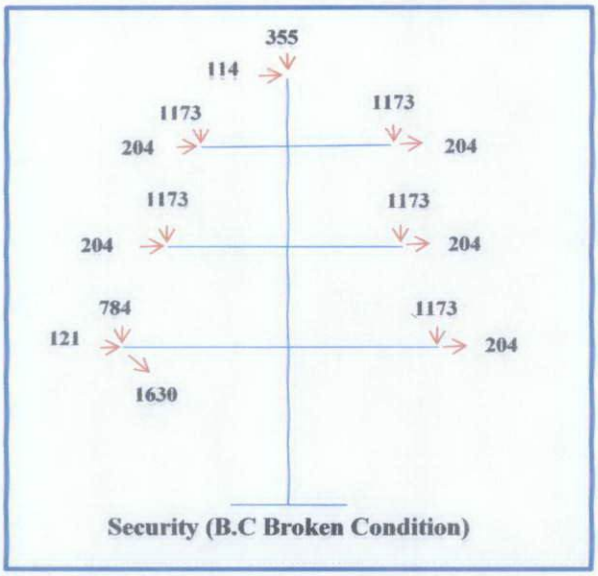


**Figure 4.19: Security (BC Broken Condition)**
**BS 8100**

#### 4.4.2.2 Tree Diagram for IS 802

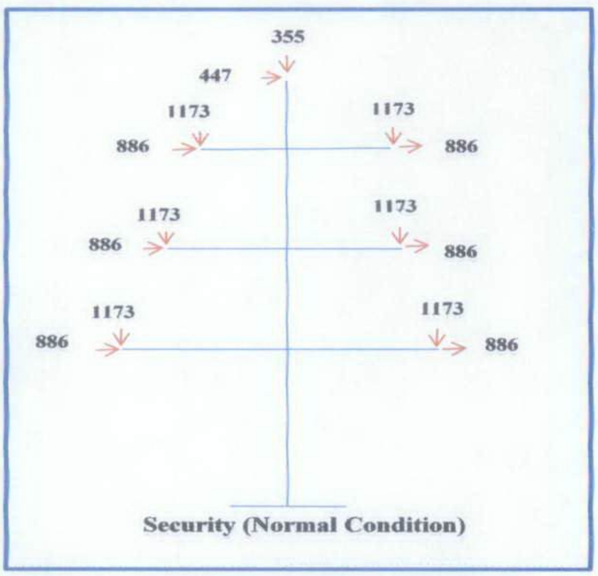


**Figure 4.20: Security (Normal Condition)**
**IS 802**

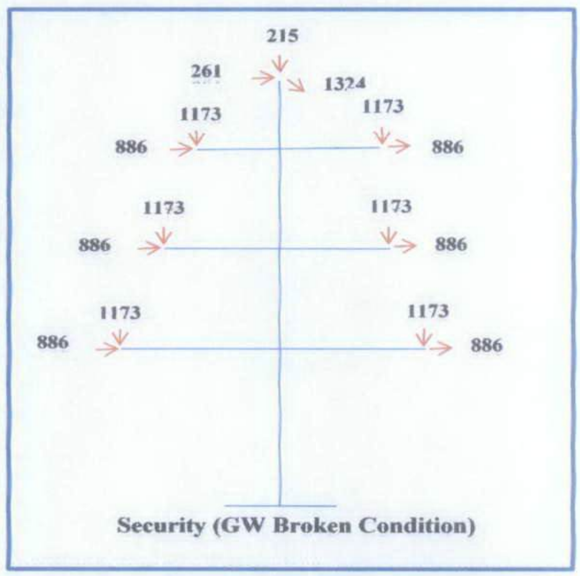


**Figure 4.21: Security (GW Broken Condition)**
**IS 802**

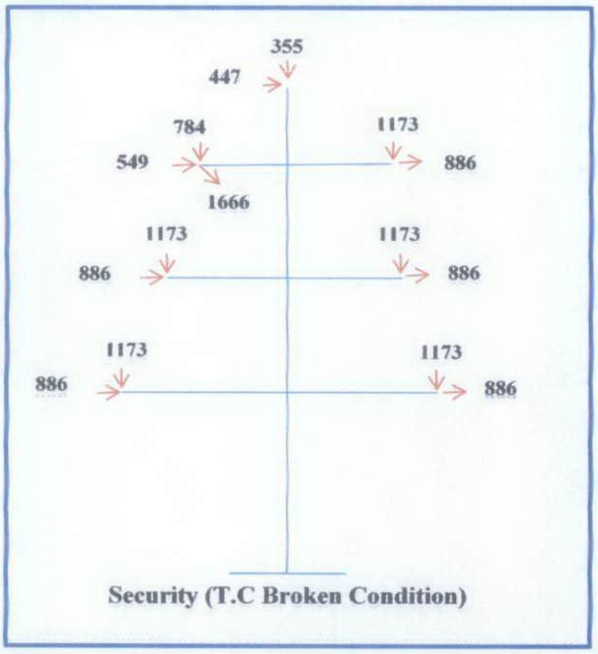


**Figure 4.22: Security (TC Broken Condition) IS 802**

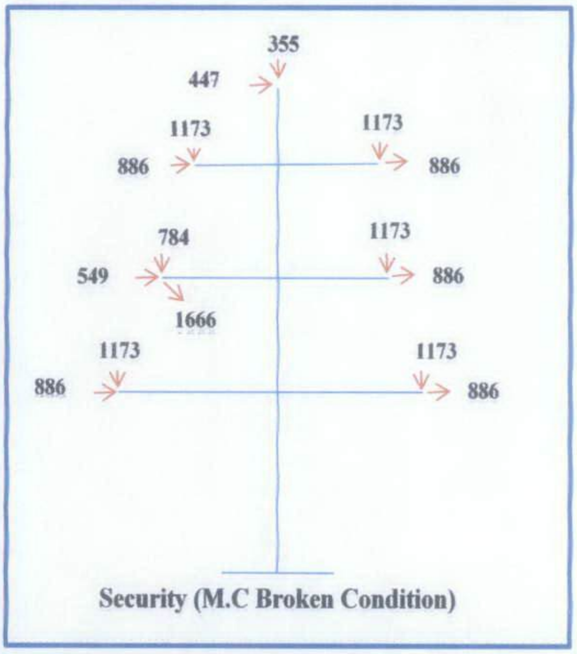


**Figure 4.23: Security (MC Broken Condition) IS 802**

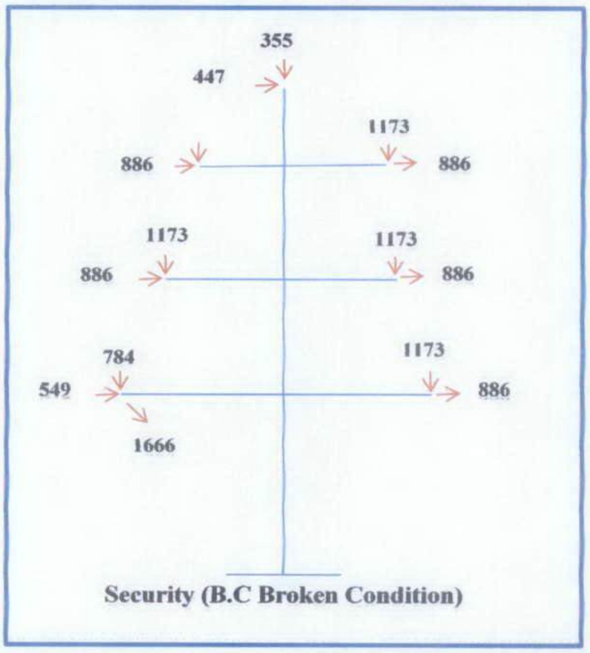


**Figure 4.24: Security (BC Broken Condition) IS 802**

### 4.4.2.3 Tree Diagram for MS 1553

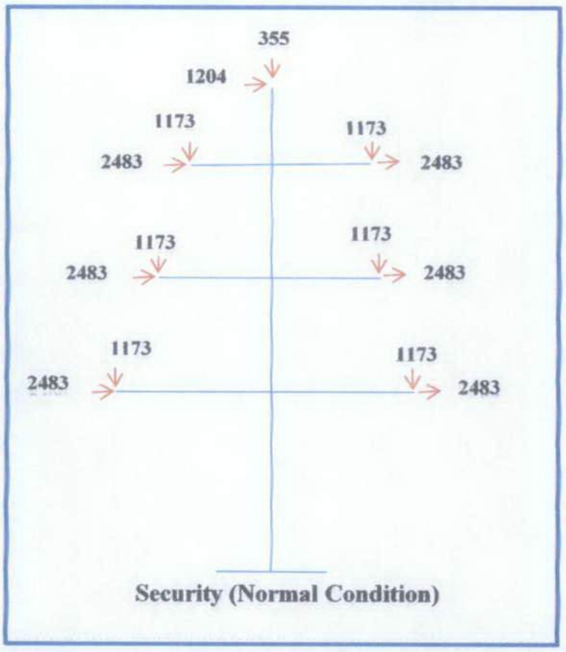


**Figure 4.25: Security (Normal Condition) MS 1553**

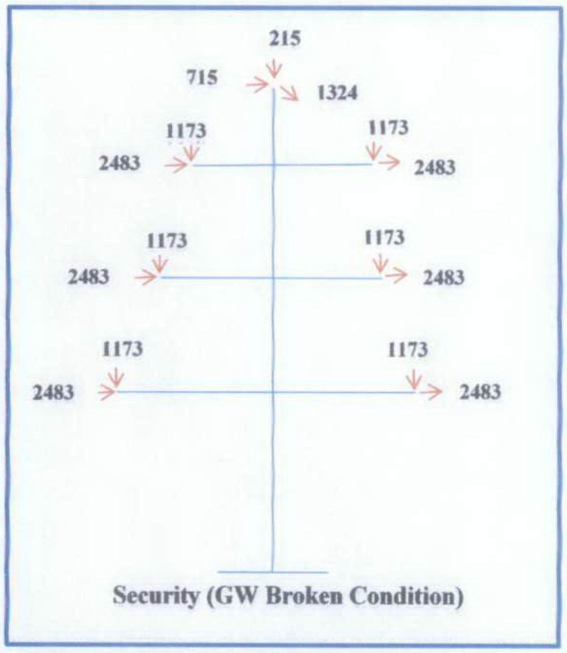


**Figure 4.26: Security (GW Broken Condition) MS 1553**

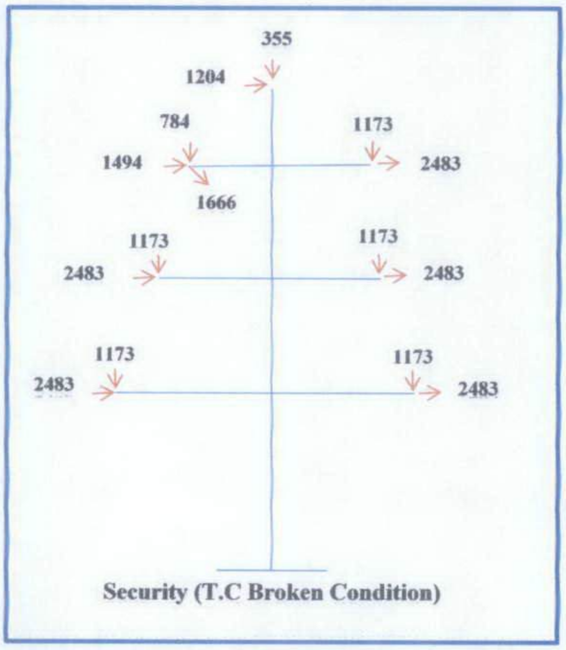


**Figure 4.27: Security (TC Broken Condition) MS 1553**

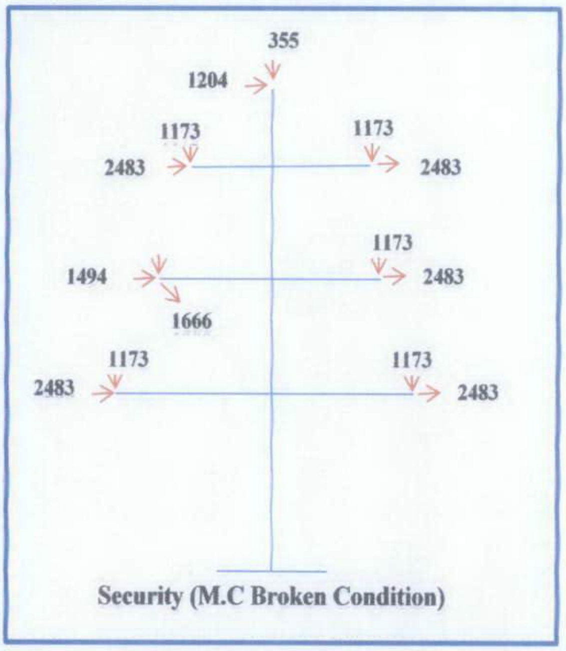


**Figure 4.28: Security (MC Broken Condition) MS 1553**

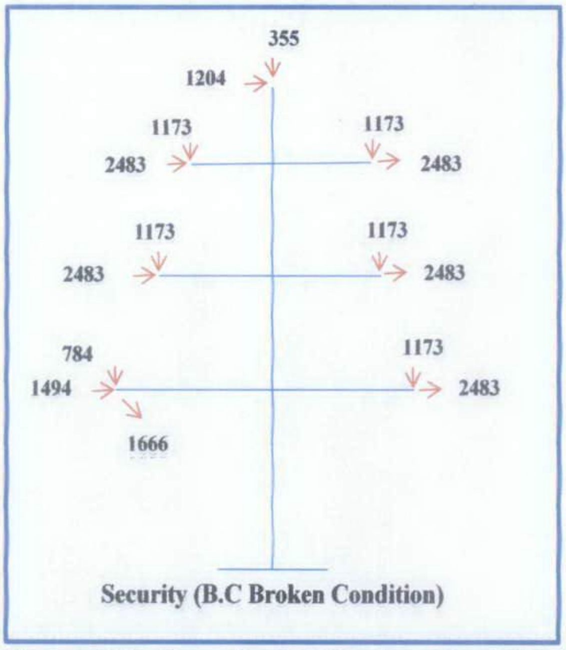


**Figure 4.29: Security (BC Broken Condition) MS 1553**

### 4.4.3 Safety Condition

#### 4.4.3.1 Tree Diagram for BS 8100

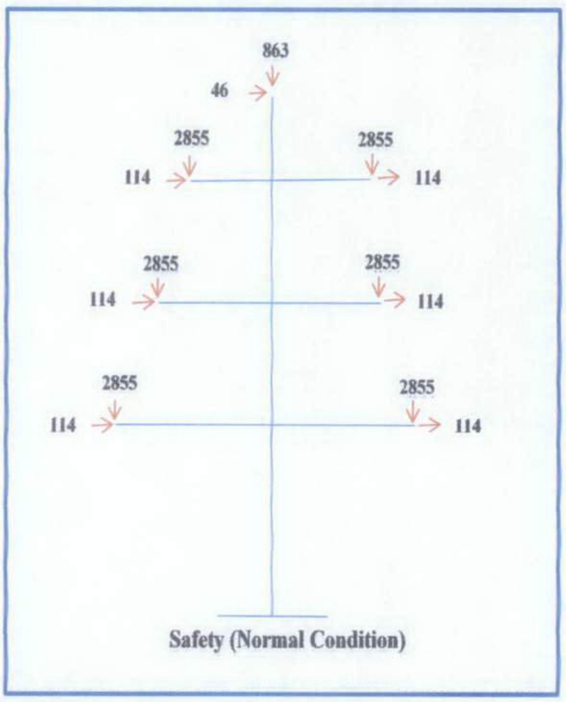


**Figure 4.30: Safety (Normal Condition) BS 8100**

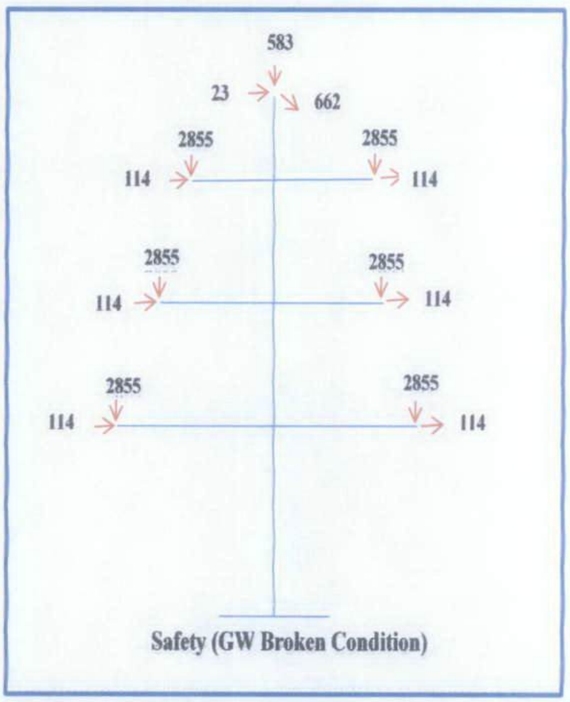


**Figure 4.31: Safety (GW Broken Condition) BS 8100**

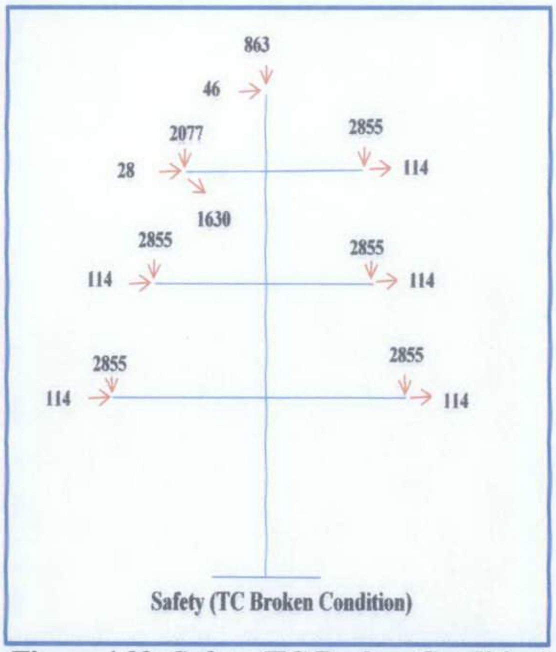


**Figure 4.32: Safety (TC Broken Condition) BS 8100**

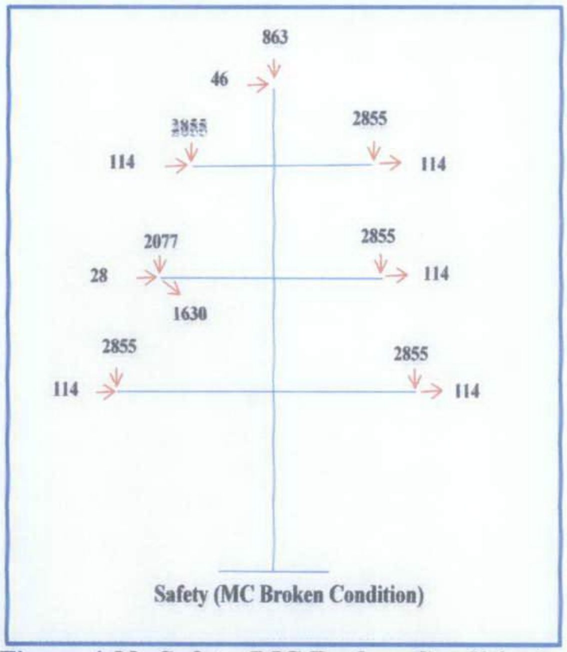


**Figure 4.33: Safety (MC Broken Condition) BS 8100**

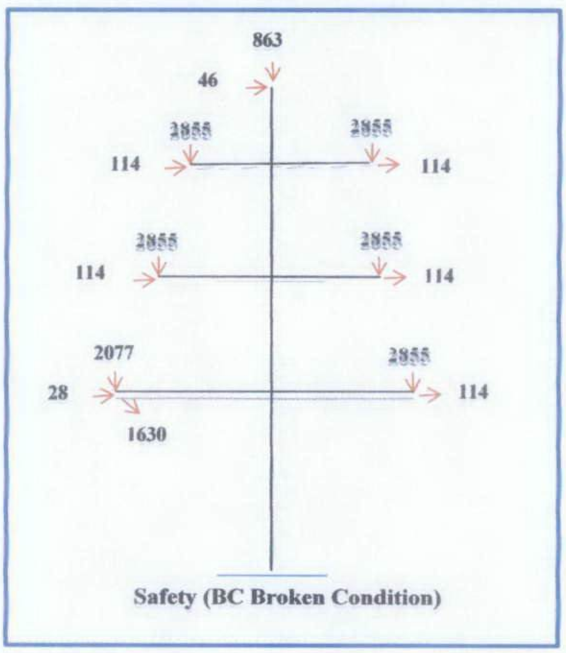


**Figure 4.34: Safety (BC Broken Condition) BS 8100**

### 4.4.3.2 Tree Diagram for IS 802

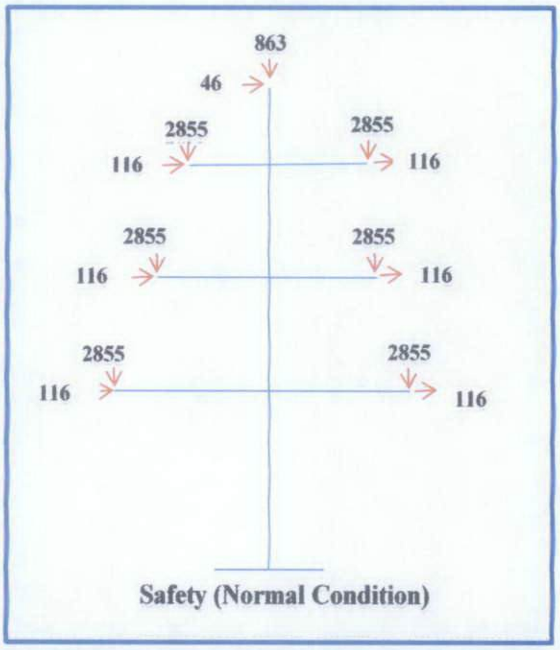


Figure 4.35: Safety (Normal Condition) IS 802

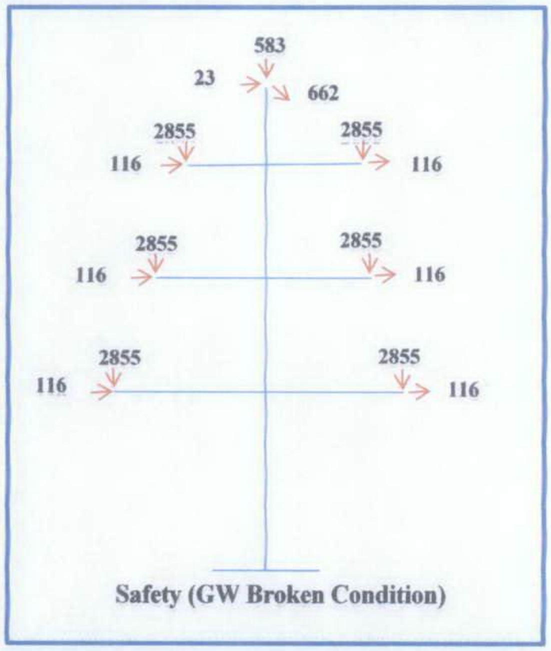


Figure 4.36: Safety (GW Broken Condition) IS 802

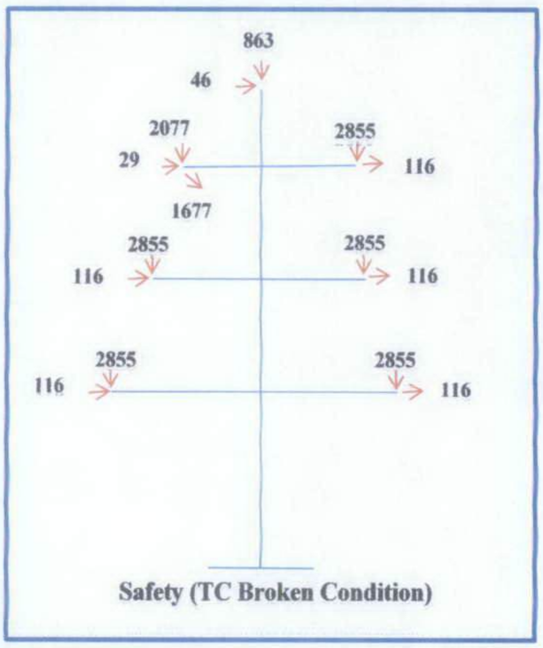


Figure 4.37: Safety (TC Broken Condition) IS 802

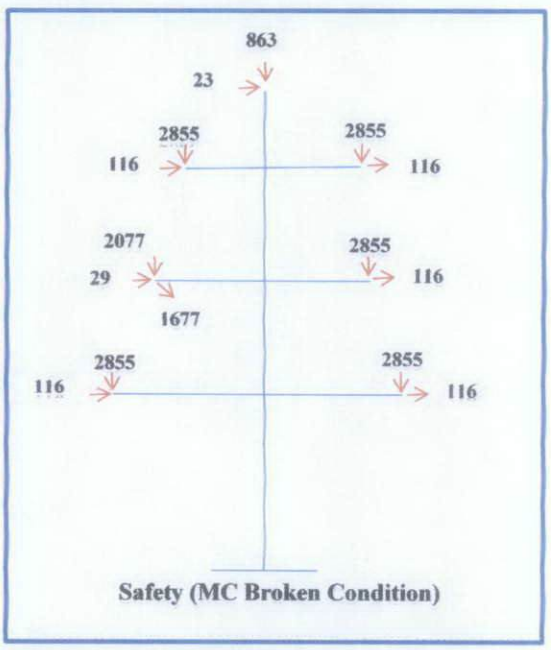


Figure 4.38: Safety (MC Broken Condition) IS 802

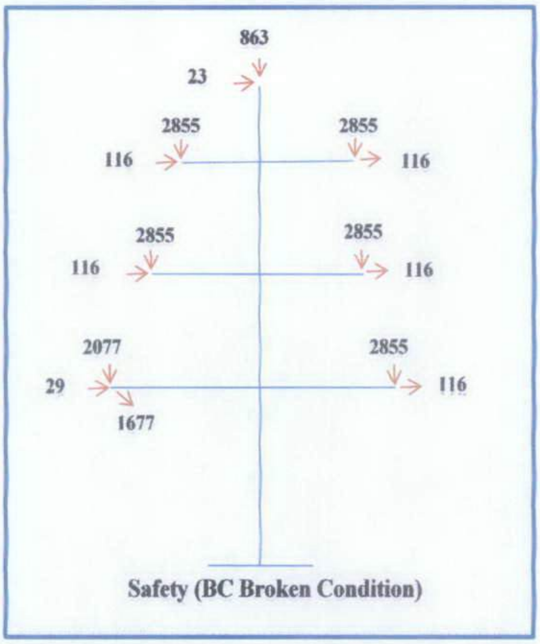


**Figure 4.39: Safety (BC Broken Condition) IS 802**

### 4.4.3.3 Tree Diagram for MS 1553

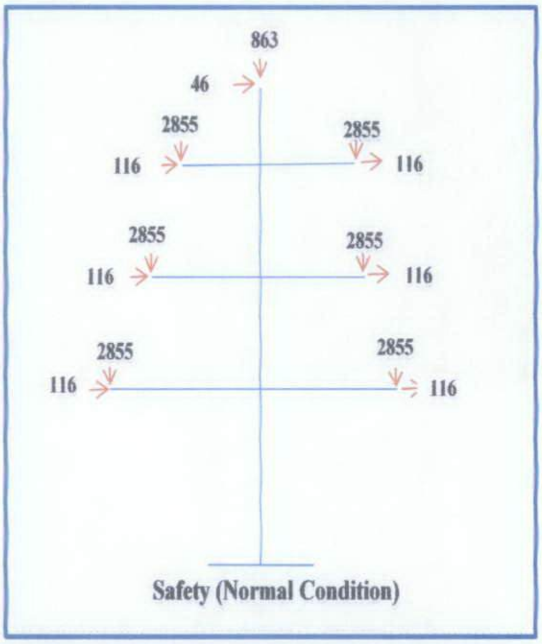


**Figure 4.40: Safety (Normal Condition) MS 1553**

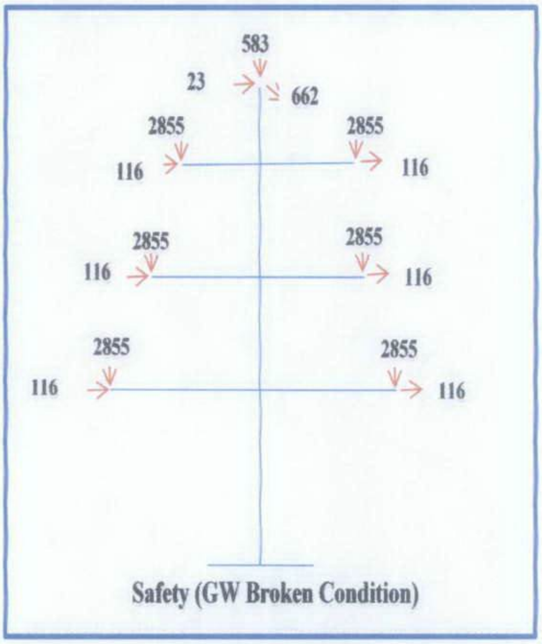


**Figure 4.41: Safety (GW Broken Condition) MS 1553**

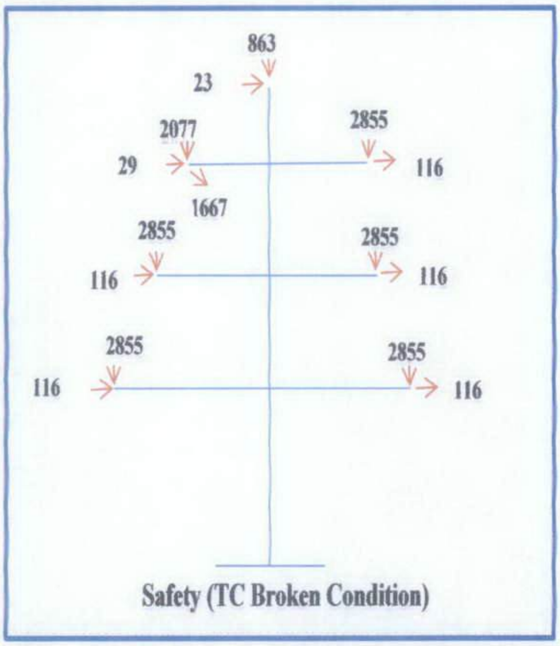


**Figure 4.42: Safety (TC Broken Condition) MS 1553**


**Figure 4.43: Safety (MC Broken Condition) MS 1553**

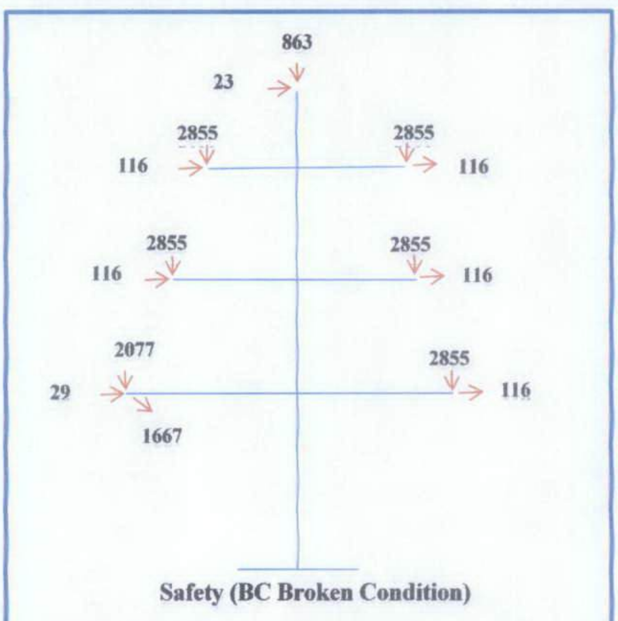


**Figure 4.44: Safety (BC Broken Condition) MS 1553**

**Note:**

All loads in the Tree Diagram are in Kg. For analysis using Staad Pro, the load will be converted into Kilo Newton (kN).

**Discussion:**

1) Tree Diagrams are used to visualize the loading acting on tower peak and cross arm tips based on Reliability, Security and Safety conditions. The value for the loading will be used in Staad Pro analysis for all cases such as normal condition and broken conductor condition.

2) The loading acting on the tower peak and cross arm tips in transverse, vertical and longitudinal direction.

3) For normal condition, the load only acting on transverse and vertical direction. For broken wire condition, there will be a longitudinal load acting as the resultant load for transverse and vertical loads.

4) For reliability condition, the transverse loads are calculated based on wind action on tower structures, conductors, ground wires and insulator string. It also takes into account the component of mechanical tension of conductor and ground wire due to wind action. For vertical loads, the loads are subjected to weight of conductors/ground wire based on design weight span and weight of insulator strings. There are no longitudinal loads for suspension tower as mention in clause 12.3.1 (IS 802: Part 1/Sec: 1995).

5) For security condition, the transverse loads for suspension tower due to wind action on tower body, conductors, ground wires and also insulators. The transverse loads also subjected to line deviation based on component of mechanical tension of conductors and ground wires at daily temperature and not including wind condition. The vertical loads due to weight of conductors/ground wire based on design weight span and weight of insulators strings. The longitudinal load for suspension should be 50 percents of the mechanical tension of conductor and 100 percent of mechanical tension of ground wire under daily temperature.

6) For safety condition, the transverse loads only due to mechanical tension of conductors and ground wire at daily temperature for both normal and broken wire conditions. The verticals loads subjected to weight of conductor, insulator, ground wire clamp and man with tools. The longitudinal loads subjected to conductor and ground wire weight due to line deviations.

7) After Tree Diagrams are produced, Staad Pro analysis was performed and the tower deflection will be recorded and analyzed to compare which cases will have higher deflection.

## 4.5 Tower Deflection Based on Loading Condition

### 4.5.1 Reliability Condition

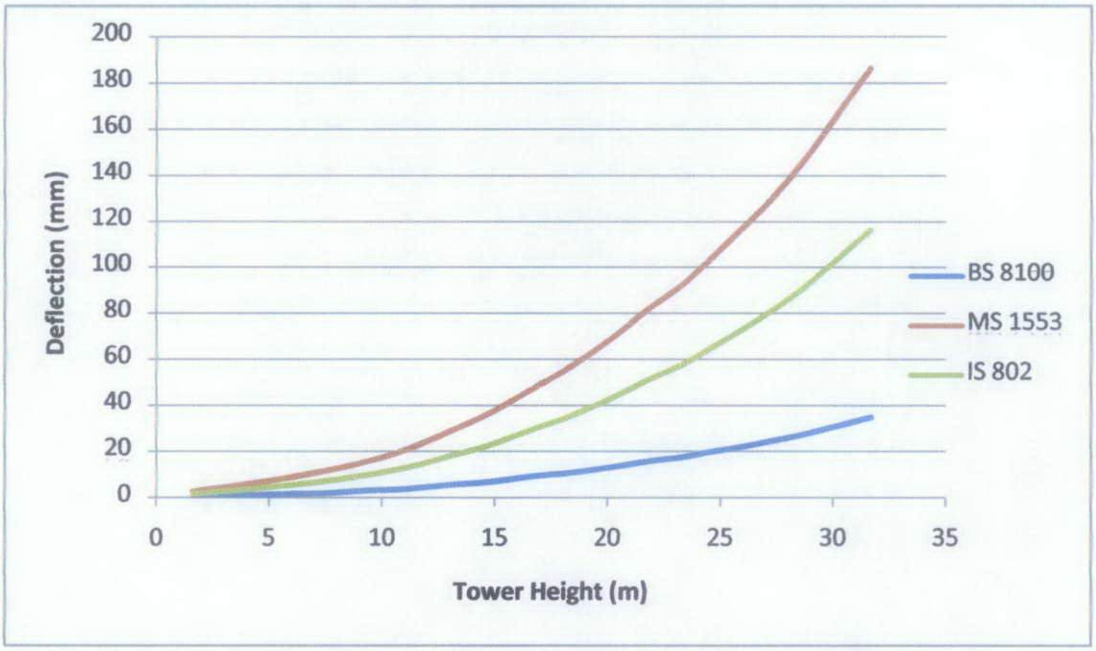


**Figure 4.45: Tower Deflection based on Reliability (Normal Condition)**

**Discussion:**

1) As stated in Clause 4.2 (IS 802: Part 1/Sec 1:1995), reliability of transmission system is the probability that system would perform its function/task under the designed load conditions for specific period. The reliability may be define as the probability that a given item will indeed survive a given services environment and loading for a prescribed period of time.

2) Based on Figure 4.45, we can conclude that MS 1553 have highest tower deflection under reliability condition followed by IS 802 and BS 8100. This is due to higher design wind pressure as it will caused the wind load acting on tower body, conductor and ground wire become higher. Higher design wind pressure also causes the mechanical tension of conductors and ground wire come higher.

3) The tower deflection increases with tower height. Upper part of tower will have more deflection compared to the lowest part of tower.

### 4.5.2 Security Condition

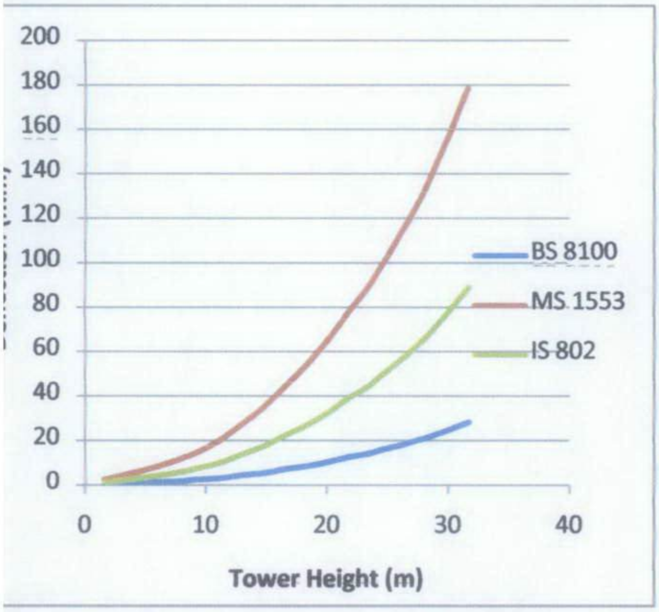


**Figure 4.46: Tower Deflection based on Security (Normal Condition)**

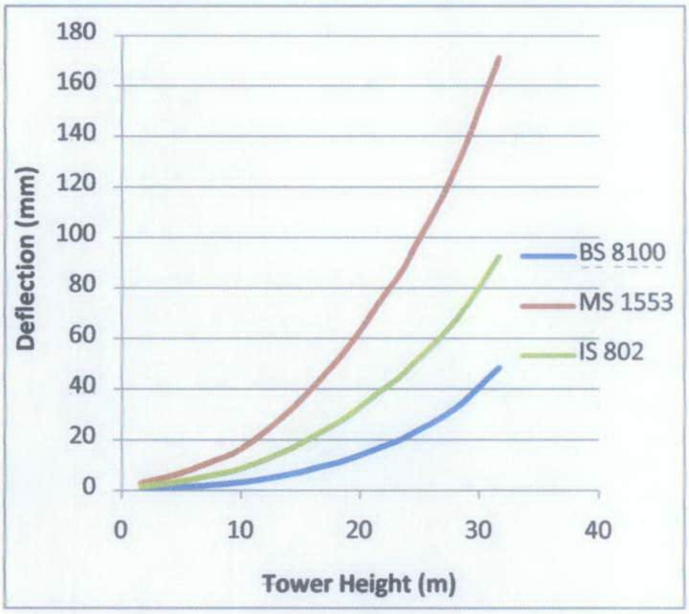


**Figure 4.47: Tower Deflection based on Security (GW Broken Condition)**

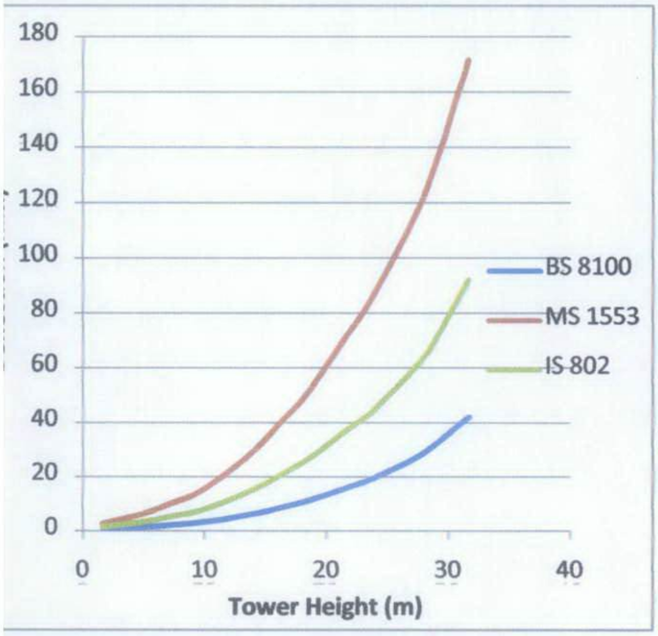


**Figure 4.48: Tower Deflection based on Security (TC Broken Condition)**

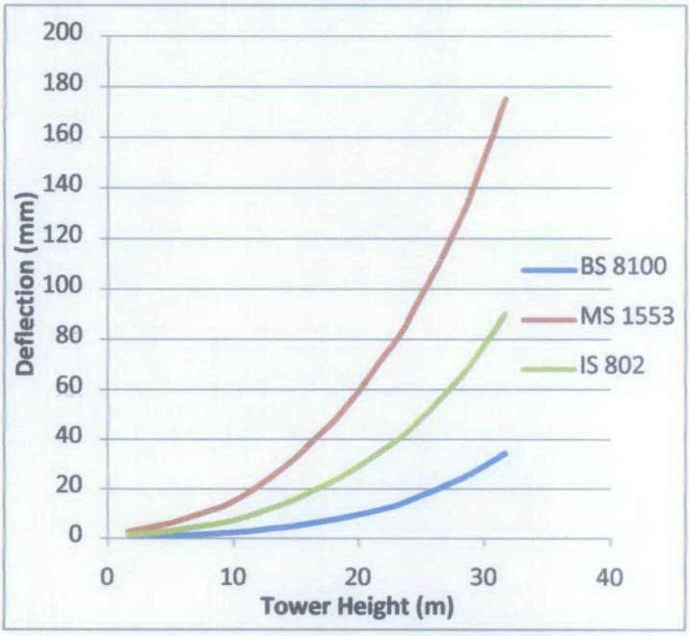


**Figure 4.49: Tower Deflection based on Security (MC Broken Condition)**

Note: GW – Ground Wire TC – Top Conductor

MC – Middle Conductor BC – Bottom Conductor

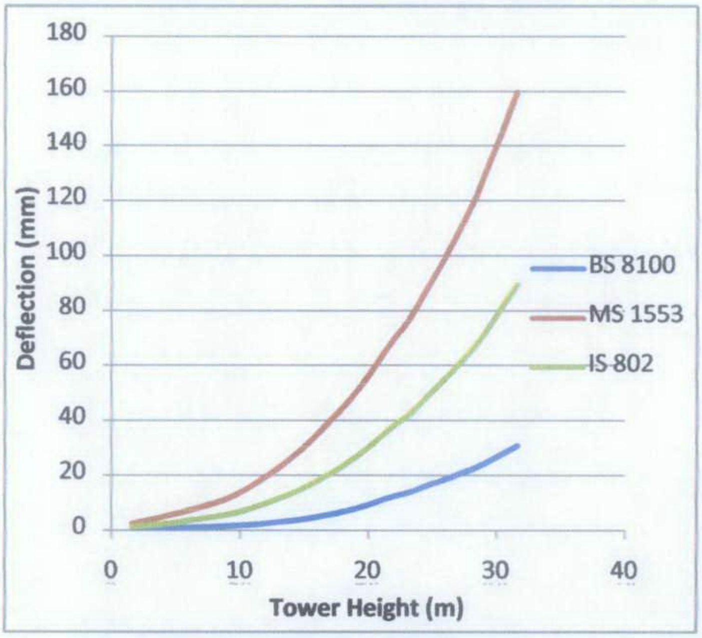


**Figure 4.50: Tower Deflection based on Security (BC Broken Condition)**

**Discussion:**

1) As stated in Clause 4.3 (IS 802: Part 1/Sec 1:1995), security is the ability of a system to be protected from any major collapse such as cascading effect, if a failure is triggered in a given component. Security is a deterministic concept as opposed to reliability which is probabilistic.

2) For security conditions, MS 1553 have greater tower deflection compared to IS 802 and BS 8100. MS 1553 have greater design wind pressure compared to IS 802 and BS 8100. Higher design wind pressure will caused the mechanical tension become higher and will affect the tower deflection.

3) Tower deflections for security conditions are lower than reliability condition because for security condition, it didn't take into account transverse load due to wind action on tower body, conductors, ground wire and insulators. For broken wire spans the component only take 50 percent of mechanical tension of conductor and 100 percent mechanical tension of ground wire. Another reason is because the vertical loads for security conditions (broken wire condition) are lower than reliability condition. As stated in Clause 12.2.2 (IS 802: Part 1/Sec 1:1995), for broken wire condition the load due to weight for conductor/ground wire shall be considered only 60 percent of weight span. So, the load due to weight of conductor and ground wire will be lower.

### 4.5.3 Safety Condition

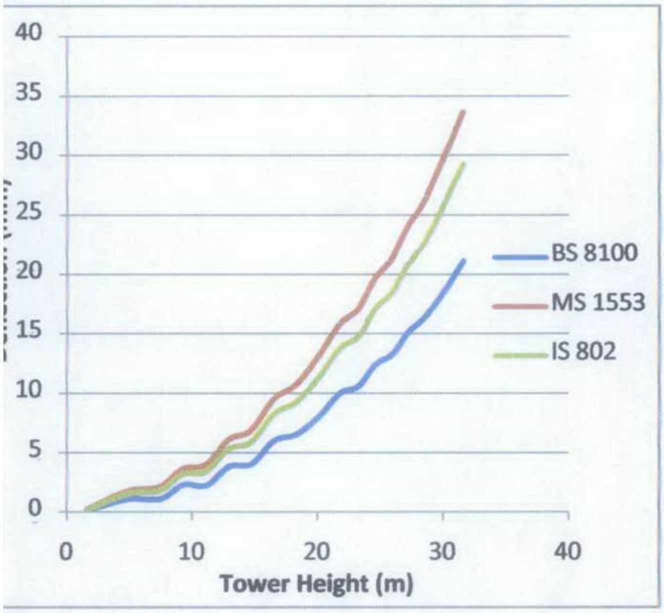


**Figure 4.51: Tower Deflection based on Safety (Normal Condition)**

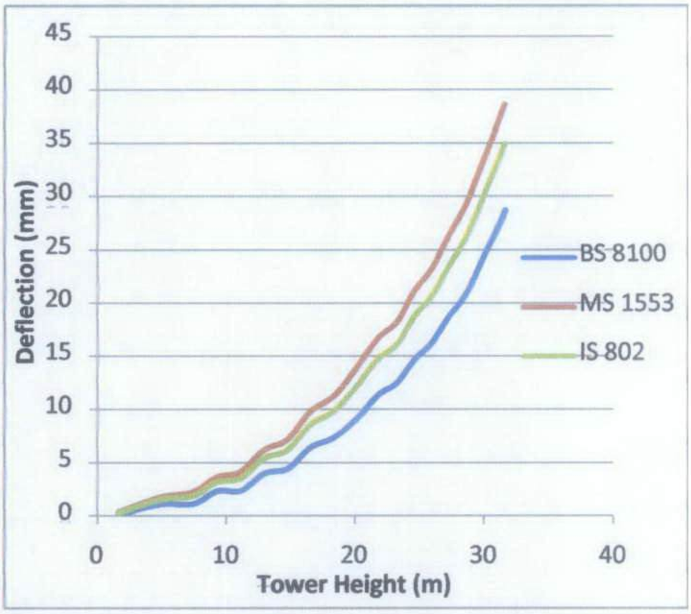


**Figure 4.52: Tower Deflection based on Safety (GW Broken Condition)**

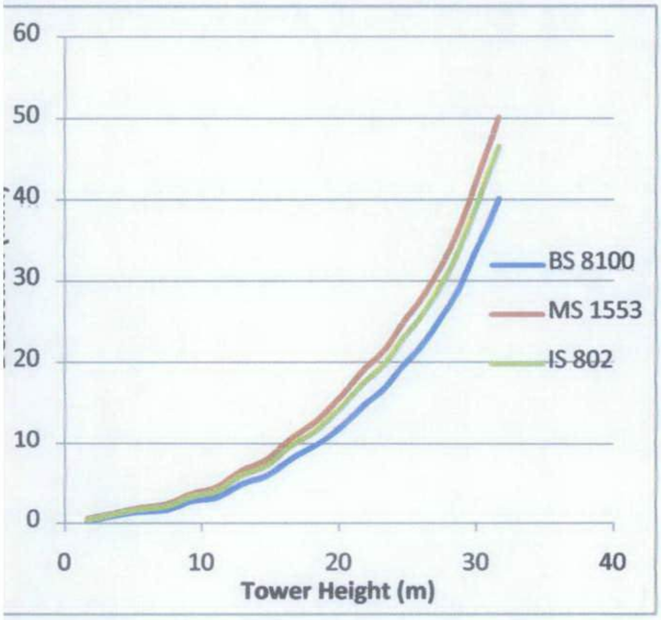


**Figure 4.53: Tower Deflection based on Safety (TC Broken Condition)**

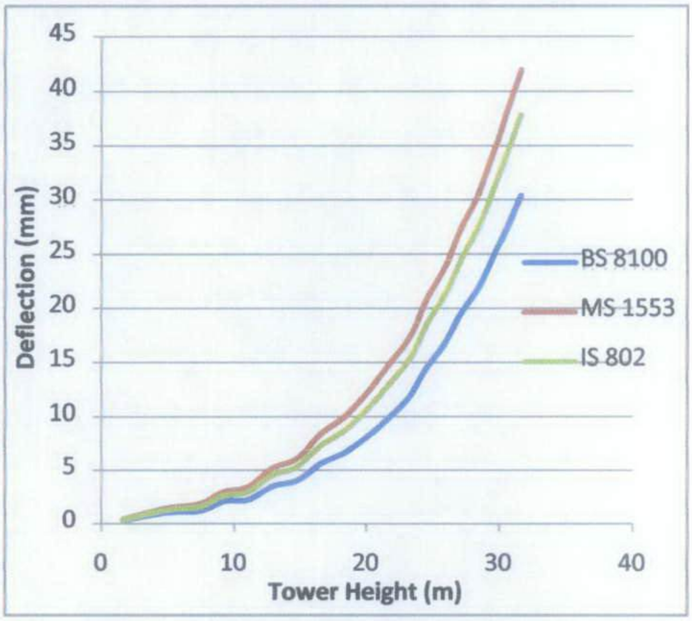


**Figure 4.54: Tower Deflection based on Safety (MC Broken Condition)**

Note: GW – Ground Wire TC – Top Conductor

MC – Middle Conductor BC – Bottom Conductor

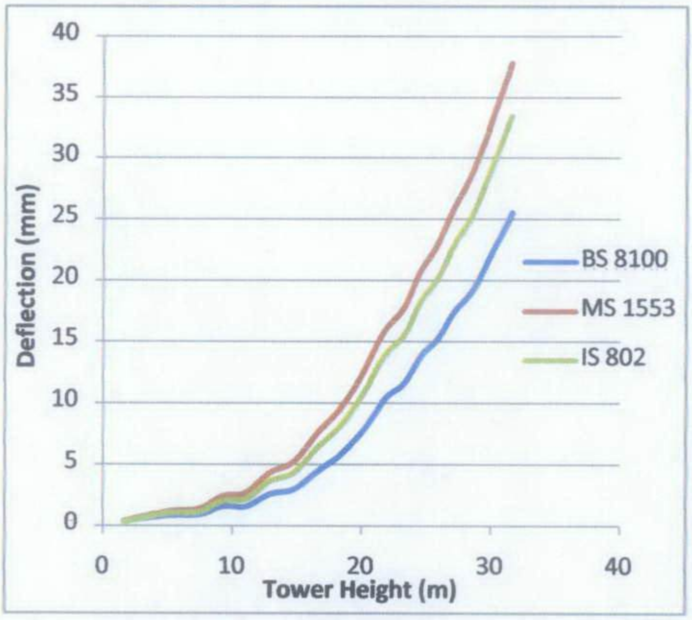


**Figure 4.55: Tower Deflection based on Safety (BC Broken Condition)**

**Discussion:**

1) As stated in Clause 4.4 (IS 802: Part 1/Sec 1:1995), safety is the ability of a system not to cause human injuries or loss of life. It relates the protection of workers during construction and maintenance operations.

2) For safety condition, MS 1553 have the highest tower deflection compared to IS 802 and BS 8100. This is due to high design wind pressure in MS 1553 design and it caused the mechanical tensions for loading computation become higher. However, the tower deflection for safety conditions based on the three codes is smaller compared to reliability and security conditions because for safety condition, the transverse loads only due to mechanical tension of conductor and ground wire for line deviation and it doesn't not take account the wind load on tower body, conductors, ground wires and insulators.

3) The differences between tower deflection between the three codes also smalls because the tower, conductor, ground wire and insulator are no subjected to wind loads. The wind loads for all codes of practices have a large difference between each other's so it will cause the difference in tower deflection become higher.

4) Tower deflection increases with tower height. Upper part of tower will have higher deflection compared to bottom part of tower.

### 4.5 Serviceability Limit States (Deflection)

According to Clause 2.5.2 (BS 5950: Part 1: 2000), the deflections of a building or part under serviceability loads should not impair the strength or efficiency of the structures or its components nor cause damage to the finishes.

- Deflection(Cantilever)=Length(Height) / 180

| Load Combination | BS 8100 | MS 1553 | IS 802 |
|---|---|---|---|
| Reliability (Normal) | 34.921 | 182.1 | 116.153 |
| Security (Normal) | 28.445 | 178.435 | 88.714 |
| Security (GW Broken) | 48.412 | 171.111 | 92.304 |
| Security (TC Broken) | 42.288 | 171.392 | 91.933 |
| Security (MC Broken) | 34.139 | 175.052 | 90.098 |
| Security (BC Broken) | 30.798 | 159.668 | 89.459 |
| Safety (Normal) | 21.159 | 33.647 | 29.247 |
| Safety (GW Broken) | 28.69 | 38.598 | 34.918 |
| Safety (TC Broken) | 40.109 | 50.136 | 46.599 |
| Safety (MC Broken) | 30.388 | 41.93 | 37.837 |
| Safety (BC Broken) | 25.539 | 37.771 | 33.45 |
| **L/180** | **186.222** | **186.222** | **186.222** |

**Table 4.18: Maximum Tower Deflection**

**Discussion:**

1) All tower deflection satisfies the serviceability limit states for Reliability, Security and Safety conditions. The tower is safe.

# CHAPTER 5

# CONCLUSION & RECOMMENDATION FOR FUTURE WORK

## 5.1 Conclusion

Wind load acting on the transmission line tower has been calculated using 3 different codes which are BS 8100, IS 802 and MS 1553. The tower dimension and environmental condition for each case is same. Using BS 8100 and MS 1553, we can see that the design wind speed increases with height of panel from ground level. In IS 802, the design wind speed is same at each height because it didn't take account of panel height in the equation as stated in the code of practices.

The gust response factor for BS 8100 and MS 1553 nearly same because the meteorological conditions in Malaysia and UK are not extreme as compared in India. The gust response factor also depends on terrain categories. In IS 802, terrain category 3(terrain with numerous closely spaced obstruction) have higher value of Gust Response Factor compare to another 2 categories. It can be concluded that Gust Response Factor is higher for area that have a lot of obstruction such as urban area and forest area.

Based on the results, it shows that MS 1553 have higher design wind pressure as compared to BS 8100 and IS 802 because for MS 1553, the equation is take into account the aerodynamic shape factor that effect the value of the design wind pressure for MS 1553. For BS 8100 and IS 802, the equation that been used to calculate the design wind pressure didn't takes into account of aerodynamic shape factor. Higher design wind pressure will cause the sag tension become higher and directly increase the loading acting on the tower body.

MS 1553 have the highest tower deflection for reliability, security and safety conditions compared to IS 802 and BS 8100. The wind loads, design wind pressure and mechanical tension of conductor and ground wire have a large effect to tower deflection. Tower deflection increases with tower height. Upper part of tower will have higher tower deflection compared to lower part of tower. This is because the upper part will subject to higher loads compared to lower part of the tower body.

For conclusion, BS 8100 is more conservative compared to MS 1553 and IS 802 in tower design. The loading and the tower deflection produced from BS 8100 is lower compared to the other 2 codes of practices. Minimum loading and tower deflection will make the tower safer. The tower deflections satisfy the serviceability limit states and it is safe.

**5.2 Recommendation for Future Work**

1) More codes of practices can be used to compare the loading acting on tower body to see which codes of practices give higher tower loadings and deflections.
2) The tower design also can take into account seismic load and the seismic analysis can be performed. This is because there's a possibility where earthquake can happen in Malaysia because Malaysia located near the ring of fire. By performing seismic analysis, the tower design can be improve and avoid failures when the earthquake occurs.
3) The tower leg members also can be design using different shape such as circular section member. The tower behavior such as deflection can be analyzed.
4) The tower behavior also can be analyzed based on different types of bracing system such as "K bracing" and "Discontinuous cross bracing with continuous horizontal".
5) Looking to vandalism (theft) cases in Malaysia, the tower can be design using different types of materials which have no scrap value. This can avoid any failures within the tower structure.

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# APPENDIX

# BS 8100

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 34.860 | -2.062 | -0.000 | 34.921 | 0.000 | 0.000 | -0.002 |
| Min X | 49 | 2:SELF WEIGI | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 25.111 | 4.758 | -0.000 | 25.557 | -0.000 | 0.000 | -0.000 |
| Min Y | 95 | 5:WIND + SEL | 14.792 | -19.178 | -0.000 | 24.220 | 0.000 | -0.000 | -0.006 |
| Max Z | 68 | 5:WIND + SEL | 0.588 | -0.531 | 0.449 | 0.911 | -0.001 | -0.000 | 0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.588 | -0.531 | -0.449 | 0.911 | 0.001 | 0.000 | 0.000 |
| Max rX | 34 | 5:WIND + SEL | 0.588 | -0.531 | -0.449 | 0.911 | 0.001 | 0.000 | 0.000 |
| Min rX | 68 | 5:WIND + SEL | 0.588 | -0.531 | 0.449 | 0.911 | -0.001 | -0.000 | 0.000 |
| Max rY | 22 | 5:WIND + SEL | 19.805 | -3.290 | -0.091 | 20.077 | 0.000 | 0.000 | -0.002 |
| Min rY | 56 | 5:WIND + SEL | 19.805 | -3.290 | 0.091 | 20.077 | -0.000 | -0.000 | -0.002 |
| Max rZ | 84 | 4:CONDUCTO | 9.997 | -3.685 | -0.000 | 10.655 | 0.000 | 0.000 | 0.003 |
| Min rZ | 95 | 5:WIND + SEL | 14.792 | -19.178 | -0.000 | 24.220 | 0.000 | -0.000 | -0.006 |
| Max Rst | 1 | 5:WIND + SEL | 34.860 | -2.062 | -0.000 | 34.921 | 0.000 | 0.000 | -0.002 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 28.371 | -2.062 | -0.000 | 28.445 | 0.000 | 0.000 | -0.002 |
| Min X | 49 | 2:SELF WEIGI | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 11.699 | -17.457 | -0.000 | 21.015 | 0.000 | -0.000 | -0.005 |
| Max Z | 68 | 5:WIND + SEL | 0.516 | -0.463 | 0.394 | 0.798 | -0.001 | -0.000 | 0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.516 | -0.463 | -0.394 | 0.798 | 0.001 | 0.000 | 0.000 |
| Max rX | 34 | 5:WIND + SEL | 0.516 | -0.463 | -0.394 | 0.798 | 0.001 | 0.000 | 0.000 |
| Min rX | 68 | 5:WIND + SEL | 0.516 | -0.463 | 0.394 | 0.798 | -0.001 | -0.000 | 0.000 |
| Max rY | 22 | 5:WIND + SEL | 15.942 | -3.020 | -0.085 | 16.226 | 0.000 | 0.000 | -0.001 |
| Min rY | 56 | 5:WIND + SEL | 15.942 | -3.020 | 0.085 | 16.226 | -0.000 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 6.790 | -5.509 | -0.000 | 8.744 | 0.000 | 0.000 | 0.004 |
| Min rZ | 95 | 5:WIND + SEL | 11.699 | -17.457 | -0.000 | 21.015 | 0.000 | -0.000 | -0.005 |
| Max Rst | 1 | 5:WIND + SEL | 28.371 | -2.062 | -0.000 | 28.445 | 0.000 | 0.000 | -0.002 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 26.844 | -2.019 | 40.238 | 48.412 | 0.003 | -0.000 | -0.001 |
| Min X | 51 | 3:GW LOAD | -0.175 | -0.210 | 0.125 | 0.301 | 0.000 | -0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 11.244 | -17.020 | 11.820 | 23.576 | 0.002 | 0.000 | -0.005 |
| Max Z | 1 | 3:GW LOAD | 1.932 | -0.067 | 40.238 | 40.284 | 0.003 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.331 | -0.235 | -0.255 | 0.479 | 0.001 | 0.000 | 0.000 |
| Max rX | 1 | 3:GW LOAD | 1.932 | -0.067 | 40.238 | 40.284 | 0.003 | -0.000 | -0.000 |
| Min rX | 51 | 2:SELF WEIGH | -0.069 | -0.080 | 0.068 | 0.125 | -0.000 | -0.000 | -0.000 |
| Max rY | 22 | 5:WIND + SEL | 15.181 | -1.083 | 16.858 | 22.712 | 0.002 | 0.000 | -0.001 |
| Min rY | 38 | 5:WIND + SEL | 16.936 | -2.763 | 19.921 | 26.293 | 0.002 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 6.790 | -5.509 | -0.000 | 8.744 | 0.000 | 0.000 | 0.004 |
| Min rZ | 95 | 5:WIND + SEL | 11.244 | -17.020 | 11.820 | 23.576 | 0.002 | 0.000 | -0.005 |
| Max Rst | 1 | 5:WIND + SEL | 26.844 | -2.019 | 40.238 | 48.412 | 0.003 | -0.000 | -0.001 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 31.367 | -1.965 | 28.294 | 42.288 | 0.002 | 0.003 | -0.002 |
| Min X | 34 | 4:CONDUCTO | -0.178 | 0.004 | -0.234 | 0.295 | 0.000 | 0.000 | 0.000 |
| Max Y | 106 | 5:WIND + SEL | 21.406 | 5.942 | 46.202 | 51.265 | -0.002 | 0.007 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 11.988 | -18.083 | -3.511 | 21.978 | 0.003 | 0.003 | -0.005 |
| Max Z | 106 | 4:CONDUCTO | 10.616 | 2.043 | 46.202 | 47.450 | -0.002 | 0.007 | 0.000 |
| Min Z | 95 | 5:WIND + SEL | 11.988 | -18.083 | -3.511 | 21.978 | 0.003 | 0.003 | -0.005 |
| Max rX | 105 | 5:WIND + SEL | 12.622 | -12.984 | -0.701 | 18.122 | 0.003 | 0.003 | -0.004 |
| Min rX | 106 | 5:WIND + SEL | 21.406 | 5.942 | 46.202 | 51.265 | -0.002 | 0.007 | -0.001 |
| Max rY | 106 | 4:CONDUCTO | 10.616 | 2.043 | 46.202 | 47.450 | -0.002 | 0.007 | 0.000 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 7.079 | -4.738 | 25.610 | 26.990 | -0.000 | 0.003 | 0.004 |
| Min rZ | 95 | 5:WIND + SEL | 11.988 | -18.083 | -3.511 | 21.978 | 0.003 | 0.003 | -0.005 |
| Max Rst | 106 | 5:WIND + SEL | 21.406 | 5.942 | 46.202 | 51.265 | -0.002 | 0.007 | -0.001 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| **All** | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 30.818 | -1.993 | 14.551 | 34.139 | 0.001 | 0.002 | -0.002 |
| Min X | 33 | 4:CONDUCTO | -0.252 | -0.055 | 0.398 | 0.474 | 0.000 | 0.000 | -0.000 |
| Max Y | 111 | 5:WIND + SEL | 21.458 | 4.455 | 23.625 | 32.225 | 0.002 | 0.003 | -0.000 |
| Min Y | 95 | 5:WIND + SEL | 12.247 | -18.536 | -14.353 | 26.450 | 0.001 | 0.004 | -0.006 |
| Max Z | 84 | 4:CONDUCTO | 7.016 | -1.660 | 35.687 | 36.408 | -0.004 | 0.007 | 0.002 |
| Min Z | 95 | 5:WIND + SEL | 12.247 | -18.536 | -14.353 | 26.450 | 0.001 | 0.004 | -0.006 |
| Max rX | 83 | 4:CONDUCTO | 2.936 | -5.130 | -3.278 | 6.758 | 0.002 | 0.002 | -0.002 |
| Min rX | 84 | 4:CONDUCTO | 7.016 | -1.660 | 35.687 | 36.408 | -0.004 | 0.007 | 0.002 |
| Max rY | 84 | 4:CONDUCTO | 7.016 | -1.660 | 35.687 | 36.408 | -0.004 | 0.007 | 0.002 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 70 | 4:CONDUCTO | 4.358 | -3.522 | 16.187 | 17.130 | -0.001 | 0.002 | 0.002 |
| Min rZ | 95 | 5:WIND + SEL | 12.247 | -18.536 | -14.353 | 26.450 | 0.001 | 0.004 | -0.006 |
| Max Rst | 84 | 5:WIND + SEL | 13.817 | 1.596 | 35.687 | 38.302 | -0.004 | 0.007 | 0.001 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 29.944 | -2.013 | 6.915 | 30.798 | 0.000 | 0.001 | -0.002 |
| Min X | 31 | 4:CONDUCTO | -0.615 | -0.359 | 1.222 | 1.415 | 0.000 | 0.000 | 0.000 |
| Max Y | 111 | 5:WIND + SEL | 21.335 | 3.779 | 12.013 | 24.775 | 0.001 | 0.001 | -0.000 |
| Min Y | 95 | 5:WIND + SEL | 12.414 | -17.893 | -7.313 | 22.973 | -0.001 | 0.002 | -0.005 |
| Max Z | 70 | 4:CONDUCTO | 4.183 | -1.244 | 18.945 | 19.441 | -0.002 | 0.004 | 0.001 |
| Min Z | 77 | 5:WIND + SEL | 6.652 | -14.116 | -9.094 | 18.061 | 0.001 | 0.003 | -0.003 |
| Max rX | 94 | 5:WIND + SEL | 13.519 | 0.829 | 14.340 | 19.726 | 0.001 | 0.002 | 0.001 |
| Min rX | 70 | 4:CONDUCTO | 4.183 | -1.244 | 18.945 | 19.441 | -0.002 | 0.004 | 0.001 |
| Max rY | 70 | 5:WIND + SEL | 8.109 | 1.230 | 18.945 | 20.644 | -0.002 | 0.004 | 0.000 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 7.509 | -4.989 | 16.187 | 18.528 | 0.001 | 0.002 | 0.004 |
| Min rZ | 95 | 5:WIND + SEL | 12.414 | -17.893 | -7.313 | 22.973 | -0.001 | 0.002 | -0.005 |
| Max Rst | 1 | 5:WIND + SEL | 29.944 | -2.013 | 6.915 | 30.798 | 0.000 | 0.001 | -0.002 |

| | | | |
|---|---|---|---|
| Job No | Sheet No 1 | Rev | |
| Software licensed to | Part | | |
| Job Title 275 kV Double Circuit (BS 8100) | Ref Wind + Selfweight + Safety - GW Broken Condition | | |
| | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | File 275kv with arm BS 8100 | Date/Time 19-Dec-2011 22:21 | |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| Number of Nodes | 127 | Highest Node | 127 |
|---|---|---|---|
| Number of Elements | 374 | Highest Beam | 374 |

| Number of Basic Load Cases | 4 |
|---|---|
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 20.061 | -3.990 | 20.119 | 28.690 | 0.002 | -0.000 | -0.001 |
| Min X | 77 | 4:CONDUCTO | -0.193 | -17.795 | -0.000 | 17.796 | -0.000 | 0.000 | -0.006 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 6.972 | -27.977 | 5.910 | 29.432 | 0.001 | 0.000 | -0.011 |
| Max Z | 1 | 3:GW LOAD | 0.703 | -0.181 | 20.119 | 20.132 | 0.002 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.509 | -0.430 | -0.410 | 0.782 | 0.001 | 0.000 | 0.000 |
| Max rX | 1 | 5:WIND + SEL | 20.061 | -3.990 | 20.119 | 28.690 | 0.002 | -0.000 | -0.001 |
| Min rX | 68 | 5:WIND + SEL | 0.687 | -0.647 | 0.540 | 1.087 | -0.001 | 0.000 | 0.000 |
| Max rY | 22 | 5:WIND + SEL | 11.345 | -3.439 | 8.345 | 14.497 | 0.001 | 0.000 | -0.001 |
| Min rY | 5 | 5:WIND + SEL | 11.892 | -1.782 | 8.390 | 14.662 | 0.001 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 5.513 | -19.681 | -0.000 | 20.438 | 0.000 | 0.000 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 6.972 | -27.977 | 5.910 | 29.432 | 0.001 | 0.000 | -0.011 |
| Max Rst | 95 | 5:WIND + SEL | 6.972 | -27.977 | 5.910 | 29.432 | 0.001 | 0.000 | -0.011 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 10 | 5:WIND + SEL | 28.161 | -3.883 | 28.294 | 40.109 | 0.002 | 0.003 | -0.002 |
| Min X | 15 | 4:CONDUCTO | -0.347 | 0.059 | 1.538 | 1.577 | 0.000 | 0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 8.307 | -29.891 | -3.511 | 31.222 | 0.003 | 0.003 | -0.011 |
| Max Z | 106 | 4:CONDUCTO | 9.387 | -2.322 | 46.202 | 47.203 | -0.002 | 0.007 | 0.002 |
| Min Z | 95 | 5:WIND + SEL | 8.307 | -29.891 | -3.511 | 31.222 | 0.003 | 0.003 | -0.011 |
| Max rX | 105 | 5:WIND + SEL | 9.925 | -20.026 | -0.701 | 22.362 | 0.003 | 0.003 | -0.008 |
| Min rX | 106 | 5:WIND + SEL | 18.994 | 0.678 | 46.202 | 49.958 | -0.002 | 0.007 | 0.001 |
| Max rY | 106 | 4:CONDUCTO | 9.387 | -2.322 | 46.202 | 47.203 | -0.002 | 0.007 | 0.002 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.639 | -17.715 | 25.610 | 31.840 | -0.000 | 0.003 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 8.307 | -29.891 | -3.511 | 31.222 | 0.003 | 0.003 | -0.011 |
| Max Rst | 106 | 5:WIND + SEL | 18.994 | 0.678 | 46.202 | 49.958 | -0.002 | 0.007 | 0.001 |

| | | Job No | Sheet No 1 | Rev |
|---|---|---|---|---|
| Software licensed to | | Part | | |
| Job Title 275 kV Double Circuit (BS 8100) | | Ref Wind + Selfweight + Safety - MC Brokenl Condition | | |
| | | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | | File 275kv with arm BS 8100 | Date/Time 19-Dec-2011 21:27 | |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 26.385 | -3.939 | 14.551 | 30.388 | 0.001 | 0.002 | -0.001 |
| Min X | 13 | 4:CONDUCTO | -0.897 | -0.327 | 2.087 | 2.295 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 8.662 | -30.568 | -14.353 | 34.864 | 0.001 | 0.004 | -0.011 |
| Max Z | 84 | 4:CONDUCTO | 6.363 | -11.850 | 35.687 | 38.138 | -0.004 | 0.007 | 0.007 |
| Min Z | 95 | 5:WIND + SEL | 8.662 | -30.568 | -14.353 | 34.864 | 0.001 | 0.004 | -0.011 |
| Max rX | 83 | 4:CONDUCTO | 1.709 | -9.381 | -3.277 | 10.083 | 0.002 | 0.002 | -0.004 |
| Min rX | 84 | 4:CONDUCTO | 6.363 | -11.850 | 35.687 | 38.138 | -0.004 | 0.007 | 0.007 |
| Max rY | 84 | 4:CONDUCTO | 6.363 | -11.850 | 35.687 | 38.138 | -0.004 | 0.007 | 0.007 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.363 | -11.850 | 35.687 | 38.138 | -0.004 | 0.007 | 0.007 |
| Min rZ | 95 | 5:WIND + SEL | 8.662 | -30.568 | -14.353 | 34.864 | 0.001 | 0.004 | -0.011 |
| Max Rst | 84 | 5:WIND + SEL | 12.553 | -9.239 | 35.687 | 38.942 | -0.004 | 0.007 | 0.006 |

| Software licensed to | | Job No | Sheet No 1 | Rev |
|---|---|---|---|---|
| | | Part | | |
| Job Title 275 kV Double Circuit (BS 8100) | | Ref Wind + Selfweight + Safety - BC Brokenl Condition | | |
| | | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | | File 275kv with arm BS 8100 | Date/Time 19-Dec-2011 22 | |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| Number of Nodes | 127 | Highest Node | 127 |
|---|---|---|---|
| Number of Elements | 374 | Highest Beam | 374 |

| Number of Basic Load Cases | 4 |
|---|---|
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 100 | 5:WIND + SEL | 24.261 | -3.979 | 6.915 | 25.539 | 0.000 | 0.001 | -0.001 |
| Min X | 13 | 4:CONDUCTO | -1.322 | -0.478 | 1.483 | 2.043 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 8.783 | 3.479 | 0.000 | 9.447 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 8.832 | -29.159 | -7.313 | 31.333 | -0.001 | 0.002 | -0.011 |
| Max Z | 70 | 4:CONDUCTO | 4.045 | -9.339 | 18.945 | 21.505 | -0.002 | 0.004 | 0.004 |
| Min Z | 77 | 5:WIND + SEL | 4.054 | -22.871 | -9.095 | 24.945 | 0.001 | 0.003 | -0.007 |
| Max rX | 94 | 5:WIND + SEL | 11.511 | -8.336 | 14.340 | 20.190 | 0.001 | 0.002 | 0.006 |
| Min rX | 70 | 4:CONDUCTO | 4.045 | -9.339 | 18.945 | 21.505 | -0.002 | 0.004 | 0.004 |
| Max rY | 70 | 5:WIND + SEL | 7.676 | -7.265 | 18.945 | 21.693 | -0.002 | 0.004 | 0.003 |
| Min rY | 66 | 1:WIND FROM | 0.938 | -0.315 | 0.086 | 0.994 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 7.169 | -18.567 | 16.187 | 25.655 | 0.001 | 0.002 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 8.832 | -29.159 | -7.313 | 31.333 | -0.001 | 0.002 | -0.011 |
| Max Rst | 95 | 5:WIND + SEL | 8.832 | -29.159 | -7.313 | 31.333 | -0.001 | 0.002 | -0.011 |

MS 1553

| | Job No | Sheet No 1 | Rev |
|---|---|---|---|
| Software licensed to | Part | | |
| Job Title 275 kV Double Circuit (MS 1553:2002) | Ref (WIND+SelfWeight+Reliability Condition) | | |
| | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | File 275kv with arm MS 1553 | Date/Time 18-Dec-2011 13:05 | |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| | | | |
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| **Structure Type** | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | **186.351** | -2.051 | -0.000 | 186.362 | 0.000 | 0.000 | -0.010 |
| Min X | 49 | 2:SELF WEIGH | **-0.075** | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 130.104 | **48.953** | -0.000 | 139.009 | -0.000 | 0.000 | -0.008 |
| Min Y | 95 | 5:WIND + SEL | 81.005 | **-59.460** | -0.000 | 100.485 | 0.000 | -0.000 | -0.012 |
| Max Z | 68 | 5:WIND + SEL | 2.128 | -1.951 | **1.605** | 3.303 | -0.001 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND + SEL | 2.128 | -1.951 | **-1.605** | 3.303 | 0.001 | 0.000 | -0.000 |
| Max rX | 31 | 5:WIND + SEL | 14.519 | -5.819 | 0.873 | 15.666 | **0.001** | 0.000 | -0.002 |
| Min rX | 65 | 5:WIND + SEL | 14.519 | -5.819 | -0.873 | 15.666 | **-0.001** | -0.000 | -0.002 |
| Max rY | 15 | 5:WIND + SEL | 10.802 | 3.855 | 1.055 | 11.518 | -0.000 | **0.000** | -0.003 |
| Min rY | 49 | 5:WIND + SEL | 10.802 | 3.855 | -1.055 | 11.518 | 0.000 | **-0.000** | -0.003 |
| Max rZ | 77 | 2:SELF WEIGH | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | **0.000** |
| Min rZ | 95 | 5:WIND + SEL | 81.005 | -59.460 | -0.000 | 100.485 | 0.000 | -0.000 | **-0.012** |
| Max Rst | 1 | 5:WIND + SEL | 186.351 | -2.051 | -0.000 | **186.362** | 0.000 | 0.000 | -0.010 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT+ GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 178.423 | -2.051 | -0.000 | 178.435 | 0.000 | 0.000 | -0.010 |
| Min X | 49 | 2:SELF WEIGI | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 124.458 | 46.749 | -0.000 | 132.949 | -0.000 | 0.000 | -0.007 |
| Min Y | 95 | 5:WIND + SEL | 77.370 | -57.355 | -0.000 | 96.310 | 0.000 | -0.000 | -0.011 |
| Max Z | 68 | 5:WIND + SEL | 2.046 | -1.872 | 1.541 | 3.173 | -0.001 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND + SEL | 2.046 | -1.872 | -1.541 | 3.173 | 0.001 | 0.000 | -0.000 |
| Max rX | 31 | 5:WIND + SEL | 13.876 | -5.591 | 0.840 | 14.984 | 0.001 | 0.000 | -0.002 |
| Min rX | 65 | 5:WIND + SEL | 13.876 | -5.591 | -0.840 | 14.984 | -0.001 | -0.000 | -0.002 |
| Max rY | 15 | 5:WIND + SEL | 10.324 | 3.659 | 1.000 | 10.999 | -0.000 | 0.000 | -0.002 |
| Min rY | 49 | 5:WIND + SEL | 10.324 | 3.659 | -1.000 | 10.999 | 0.000 | -0.000 | -0.002 |
| Max rZ | 77 | 2:SELF WEIGI | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | 0.000 |
| Min rZ | 95 | 5:WIND + SEL | 77.370 | -57.355 | -0.000 | 96.310 | 0.000 | -0.000 | -0.011 |
| Max Rst | 1 | 5:WIND + SEL | 178.423 | -2.051 | -0.000 | 178.435 | 0.000 | 0.000 | -0.010 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 166.301 | -2.008 | 40.238 | 171.111 | 0.003 | 0.000 | -0.009 |
| Min X | 51 | 3:GW LOAD | -0.124 | -0.125 | 0.055 | 0.185 | 0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 117.484 | 42.227 | 22.982 | 126.940 | 0.003 | -0.000 | -0.006 |
| Min Y | 95 | 5:WIND + SEL | 73.763 | -54.053 | 11.820 | 92.209 | 0.002 | 0.000 | -0.011 |
| Max Z | 1 | 3:GW LOAD | 17.619 | -0.067 | 40.238 | 43.926 | 0.003 | -0.000 | -0.001 |
| Min Z | 34 | 5:WIND + SEL | 1.827 | -1.587 | -1.355 | 2.773 | 0.001 | 0.000 | -0.000 |
| Max rX | 1 | 5:WIND + SEL | 166.301 | -2.008 | 40.238 | 171.111 | 0.003 | 0.000 | -0.009 |
| Min rX | 68 | 5:WIND + SEL | 2.184 | -2.022 | 1.616 | 3.387 | -0.001 | -0.000 | -0.000 |
| Max rY | 25 | 5:WIND + SEL | 62.224 | -6.666 | 8.727 | 63.186 | 0.001 | 0.000 | -0.006 |
| Min rY | 49 | 5:WIND + SEL | 9.831 | 2.916 | 0.124 | 10.255 | 0.001 | -0.001 | -0.002 |
| Max rZ | 77 | 2:SELF WEIGH | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | 0.000 |
| Min rZ | 95 | 5:WIND + SEL | 73.763 | -54.053 | 11.820 | 92.209 | 0.002 | 0.000 | -0.011 |
| Max Rst | 1 | 5:WIND + SEL | 166.301 | -2.008 | 40.238 | 171.111 | 0.003 | 0.000 | -0.009 |

| Software licensed to | | Job No | Sheet No 1 | Rev |
|---|---|---|---|---|
| | | Part | | |
| Job Title | 275 kV Double Circuit (MS 1553:2002) | Ref (WIND+SelfWeight+Security - TC Broken Condition | | |
| | | By Shafiq | Date 08-Nov-11 | Chd |
| Client | Final Year Project (Civil Engineering UTP) | File 275kv with arm MS 1553 | Date/Time 18-Dec-2011 13 | |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 168.922 | -1.956 | 28.923 | 171.392 | 0.002 | 0.003 | -0.010 |
| Min X | 49 | 2:SELF WEIGI | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 116.913 | 45.972 | 47.229 | 134.211 | -0.002 | 0.007 | -0.008 |
| Min Y | 117 | 5:WIND + SEL | 116.110 | -54.756 | -2.960 | 128.407 | 0.002 | 0.005 | -0.010 |
| Max Z | 106 | 4:CONDUCTO | 82.096 | 28.725 | 47.229 | 98.972 | -0.002 | 0.007 | -0.004 |
| Min Z | 95 | 5:WIND + SEL | 72.788 | -54.220 | -3.589 | 90.834 | 0.003 | 0.003 | -0.011 |
| Max rX | 105 | 5:WIND + SEL | 74.580 | -44.440 | -0.717 | 86.819 | 0.003 | 0.003 | -0.010 |
| Min rX | 106 | 4:CONDUCTO | 82.096 | 28.725 | 47.229 | 98.972 | -0.002 | 0.007 | -0.004 |
| Max rY | 106 | 4:CONDUCTO | 82.096 | 28.725 | 47.229 | 98.972 | -0.002 | 0.007 | -0.004 |
| Min rY | 49 | 5:WIND + SEL | 10.278 | 2.889 | 0.824 | 10.708 | 0.001 | -0.000 | -0.003 |
| Max rZ | 77 | 2:SELF WEIGI | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | 0.000 |
| Min rZ | 95 | 5:WIND + SEL | 72.788 | -54.220 | -3.589 | 90.834 | 0.003 | 0.003 | -0.011 |
| Max Rst | 1 | 5:WIND + SEL | 168.922 | -1.956 | 28.923 | 171.392 | 0.002 | 0.003 | -0.010 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | **174.408** | -1.983 | 14.875 | 175.052 | 0.001 | 0.002 | -0.010 |
| Min X | 49 | 2:SELF WEIGI | **-0.075** | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND + SEL | 121.067 | **46.205** | 26.180 | 132.202 | 0.002 | 0.003 | -0.007 |
| Min Y | 95 | 5:WIND + SEL | 74.508 | **-56.700** | -14.672 | 94.771 | 0.001 | 0.005 | -0.011 |
| Max Z | 84 | 4:CONDUCTO | 55.411 | 26.706 | **36.481** | 71.515 | -0.004 | 0.007 | -0.002 |
| Min Z | 95 | 5:WIND + SEL | 74.508 | -56.700 | **-14.672** | 94.771 | 0.001 | 0.005 | -0.011 |
| Max rX | 83 | 4:CONDUCTO | 32.123 | -23.599 | -3.351 | 40.000 | **0.002** | 0.002 | -0.005 |
| Min rX | 84 | 4:CONDUCTO | 55.411 | 26.706 | 36.481 | 71.515 | **-0.004** | 0.007 | -0.002 |
| Max rY | 84 | 4:CONDUCTO | 55.411 | 26.706 | 36.481 | 71.515 | -0.004 | **0.007** | -0.002 |
| Min rY | 49 | 5:WIND + SEL | 10.735 | 3.195 | 0.422 | 11.208 | 0.001 | **-0.000** | -0.003 |
| Max rZ | 77 | 2:SELF WEIGI | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | **0.000** |
| Min rZ | 95 | 5:WIND + SEL | 74.508 | -56.700 | -14.672 | 94.771 | 0.001 | 0.005 | **-0.011** |
| Max Rst | 1 | 5:WIND + SEL | 174.408 | -1.983 | 14.875 | **175.052** | 0.001 | 0.002 | -0.010 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| Number of Nodes | 127 | Highest Node | 127 |
|---|---|---|---|
| Number of Elements | 374 | Highest Beam | 374 |

| Number of Basic Load Cases | 4 |
|---|---|
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 4:CONDUCTO | 237.222 | -1.247 | 7.069 | 237.330 | 0.000 | 0.001 | -0.012 |
| Min X | 49 | 2:SELF WEIGH | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 4:CONDUCTO | 170.605 | 61.016 | 13.262 | 181.673 | 0.001 | 0.002 | -0.009 |
| Min Y | 95 | 4:CONDUCTO | 108.756 | -72.194 | -7.475 | 130.751 | -0.001 | 0.002 | -0.013 |
| Max Z | 70 | 4:CONDUCTO | 62.557 | 48.558 | 19.366 | 81.525 | -0.002 | 0.004 | -0.006 |
| Min Z | 77 | 4:CONDUCTO | 61.483 | -58.730 | -9.297 | 85.533 | 0.001 | 0.003 | -0.009 |
| Max rX | 94 | 4:CONDUCTO | 111.522 | 50.216 | 14.659 | 123.181 | 0.001 | 0.002 | -0.007 |
| Min rX | 70 | 4:CONDUCTO | 62.557 | 48.558 | 19.366 | 81.525 | -0.002 | 0.004 | -0.006 |
| Max rY | 70 | 4:CONDUCTO | 62.557 | 48.558 | 19.366 | 81.525 | -0.002 | 0.004 | -0.006 |
| Min rY | 49 | 4:CONDUCTO | 15.308 | 5.423 | -0.489 | 16.248 | 0.001 | -0.000 | -0.003 |
| Max rZ | 77 | 2:SELF WEIGH | -0.026 | -0.772 | -0.000 | 0.772 | 0.000 | -0.000 | 0.000 |
| Min rZ | 95 | 4:CONDUCTO | 108.756 | -72.194 | -7.475 | 130.751 | -0.001 | 0.002 | -0.013 |
| Max Rst | 1 | 4:CONDUCTO | 237.222 | -1.247 | 7.069 | 237.330 | 0.000 | 0.001 | -0.012 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 33.400 | -4.066 | -0.000 | 33.647 | 0.000 | 0.000 | -0.002 |
| Min X | 51 | 4:CONDUCTO | -0.173 | -0.170 | 0.171 | 0.296 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 17.689 | 6.949 | 0.000 | 19.005 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 13.162 | -31.516 | -0.000 | 34.154 | 0.000 | -0.000 | -0.012 |
| Max Z | 68 | 5:WIND + SEL | 0.861 | -0.689 | 0.598 | 1.254 | -0.001 | -0.000 | 0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.861 | -0.689 | -0.598 | 1.254 | 0.001 | 0.000 | 0.000 |
| Max rX | 34 | 5:WIND + SEL | 0.861 | -0.689 | -0.598 | 1.254 | 0.001 | 0.000 | 0.000 |
| Min rX | 68 | 5:WIND + SEL | 0.861 | -0.689 | 0.598 | 1.254 | -0.001 | -0.000 | 0.000 |
| Max rY | 22 | 5:WIND + SEL | 19.137 | -4.938 | -0.141 | 19.765 | -0.000 | 0.000 | -0.001 |
| Min rY | 56 | 5:WIND + SEL | 19.137 | -4.938 | 0.141 | 19.765 | 0.000 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 5.586 | -19.639 | -0.000 | 20.418 | 0.000 | 0.000 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 13.162 | -31.516 | -0.000 | 34.154 | 0.000 | -0.000 | -0.012 |
| Max Rst | 95 | 5:WIND + SEL | 13.162 | -31.516 | -0.000 | 34.154 | 0.000 | -0.000 | -0.012 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 32.698 | -3.979 | 20.119 | 38.598 | 0.002 | -0.000 | -0.002 |
| Min X | 51 | 4:CONDUCTO | -0.173 | -0.170 | 0.171 | 0.296 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 17.689 | 6.949 | 0.000 | 19.005 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 12.953 | -31.276 | 5.910 | 34.364 | 0.001 | 0.000 | -0.012 |
| Max Z | 1 | 3:GW LOAD | 0.703 | -0.181 | 20.119 | 20.132 | 0.002 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND + SEL | 0.765 | -0.572 | -0.526 | 1.091 | 0.001 | 0.000 | 0.000 |
| Max rX | 1 | 5:WIND + SEL | 32.698 | -3.979 | 20.119 | 38.598 | 0.002 | -0.000 | -0.002 |
| Min rX | 68 | 5:WIND + SEL | 0.944 | -0.790 | 0.657 | 1.395 | -0.001 | -0.000 | 0.000 |
| Max rY | 22 | 5:WIND + SEL | 18.781 | -3.932 | 8.332 | 20.919 | 0.001 | 0.000 | -0.001 |
| Min rY | 38 | 5:WIND + SEL | 20.805 | -3.296 | 9.966 | 23.303 | 0.001 | -0.000 | -0.002 |
| Max rZ | 84 | 4:CONDUCTO | 5.586 | -19.639 | -0.000 | 20.418 | 0.000 | 0.000 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 12.953 | -31.276 | 5.910 | 34.364 | 0.001 | 0.000 | -0.012 |
| Max Rst | 1 | 5:WIND + SEL | 32.698 | -3.979 | 20.119 | 38.598 | 0.002 | -0.000 | -0.002 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | 40.766 | -3.873 | 28.928 | 50.136 | 0.002 | 0.003 | -0.002 |
| Min X | 15 | 4:CONDUCTO | -0.349 | 0.075 | 1.577 | 1.617 | 0.000 | 0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 17.689 | 6.949 | 0.000 | 19.005 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 14.275 | -33.180 | -3.589 | 36.299 | 0.003 | 0.003 | -0.012 |
| Max Z | 106 | 4:CONDUCTO | 9.477 | -2.289 | 47.236 | 48.232 | -0.002 | 0.007 | 0.002 |
| Min Z | 95 | 5:WIND + SEL | 14.275 | -33.180 | -3.589 | 36.299 | 0.003 | 0.003 | -0.012 |
| Max rX | 105 | 5:WIND + SEL | 16.003 | -22.830 | -0.717 | 27.890 | 0.003 | 0.003 | -0.008 |
| Min rX | 106 | 5:WIND + SEL | 27.989 | 4.181 | 47.236 | 55.065 | -0.002 | 0.007 | 0.001 |
| Max rY | 106 | 5:WIND + SEL | 27.989 | 4.181 | 47.236 | 55.065 | -0.002 | 0.007 | 0.001 |
| Min rY | 66 | 1:WIND FROM | 2.038 | -0.638 | 0.174 | 2.143 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.700 | -17.684 | 26.184 | 32.298 | -0.000 | 0.003 | 0.010 |
| Min rZ | 95 | 5:WIND + SEL | 14.275 | -33.180 | -3.589 | 36.299 | 0.003 | 0.003 | -0.012 |
| Max Rst | 106 | 5:WIND + SEL | 27.989 | 4.181 | 47.236 | 55.065 | -0.002 | 0.007 | 0.001 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | **39.005** | -3.928 | 14.877 | 41.930 | 0.001 | 0.002 | -0.002 |
| Min X | 13 | 4:CONDUCTO | **-0.913** | -0.313 | 2.138 | 2.346 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 17.689 | **6.949** | 0.000 | 19.005 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 14.633 | **-33.863** | -14.675 | 39.702 | 0.001 | 0.005 | -0.012 |
| Max Z | 84 | 4:CONDUCTO | 6.427 | -11.811 | **36.486** | 38.885 | -0.004 | 0.007 | 0.007 |
| Min Z | 95 | 5:WIND + SEL | 14.633 | -33.863 | **-14.675** | 39.702 | 0.001 | 0.005 | -0.012 |
| Max rX | 83 | 4:CONDUCTO | 1.731 | -9.389 | -3.350 | 10.118 | **0.002** | 0.002 | -0.004 |
| Min rX | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | **-0.004** | 0.007 | 0.007 |
| Max rY | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | -0.004 | **0.007** | 0.007 |
| Min rY | 66 | 1:WIND FROM | 2.038 | -0.638 | 0.174 | 2.143 | -0.000 | **-0.000** | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | -0.004 | 0.007 | **0.007** |
| Min rZ | 95 | 5:WIND + SEL | 14.633 | -33.863 | -14.675 | 39.702 | 0.001 | 0.005 | **-0.012** |
| Max Rst | 1 | 5:WIND + SEL | 39.005 | -3.928 | 14.877 | **41.930** | 0.001 | 0.002 | -0.002 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| **All** | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND + SELFWEIGHT + GW LOAD + CC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND + SEL | **36.890** | -3.969 | 7.070 | 37.771 | 0.000 | 0.001 | -0.002 |
| Min X | 13 | 4:CONDUCTO | **-1.348** | -0.467 | 1.521 | 2.086 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 17.689 | **6.949** | 0.000 | 19.005 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND + SEL | 14.807 | **-32.457** | -7.477 | 36.450 | -0.001 | 0.002 | -0.012 |
| Max Z | 70 | 4:CONDUCTO | 4.083 | -9.305 | **19.369** | 21.872 | -0.002 | 0.004 | 0.004 |
| Min Z | 77 | 5:WIND + SEL | 7.698 | -25.589 | **-9.298** | 28.293 | 0.001 | 0.003 | -0.007 |
| Max rX | 94 | 5:WIND + SEL | 17.599 | -5.492 | 14.661 | 23.555 | **0.001** | 0.002 | 0.005 |
| Min rX | 70 | 4:CONDUCTO | 4.083 | -9.305 | 19.369 | 21.872 | **-0.002** | 0.004 | 0.004 |
| Max rY | 70 | 5:WIND + SEL | 11.321 | -4.533 | 19.369 | 22.888 | -0.002 | **0.004** | 0.003 |
| Min rY | 66 | 1:WIND FROM | 2.038 | -0.638 | 0.174 | 2.143 | -0.000 | **-0.000** | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 7.237 | -18.527 | 16.550 | 25.875 | 0.001 | 0.002 | **0.010** |
| Min rZ | 95 | 5:WIND + SEL | 14.807 | -32.457 | -7.477 | 36.450 | -0.001 | 0.002 | **-0.012** |
| Max Rst | 1 | 5:WIND + SEL | 36.890 | -3.969 | 7.070 | **37.771** | 0.000 | 0.001 | -0.002 |

# IS 802

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 116.135 | -2.054 | -0.000 | 116.153 | 0.000 | 0.000 | -0.006 |
| Min X | 49 | 2:SELF WEIGH | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 81.376 | 28.508 | -0.000 | 86.225 | -0.000 | 0.000 | -0.004 |
| Min Y | 95 | 5:WIND+SW+( | 50.277 | -40.751 | -0.000 | 64.718 | 0.000 | -0.000 | -0.009 |
| Max Z | 68 | 5:WIND+SW+( | 1.441 | -1.293 | 1.070 | 2.212 | -0.001 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND+SW+( | 1.441 | -1.293 | -1.070 | 2.212 | 0.001 | 0.000 | -0.000 |
| Max rX | 31 | 5:WIND+SW+( | 9.149 | -3.903 | 0.594 | 9.964 | 0.001 | 0.000 | -0.001 |
| Min rX | 65 | 5:WIND+SW+( | 9.149 | -3.903 | -0.594 | 9.964 | -0.001 | -0.000 | -0.001 |
| Max rY | 15 | 5:WIND+SW+( | 6.801 | 2.214 | 0.591 | 7.177 | -0.000 | 0.000 | -0.002 |
| Min rY | 49 | 5:WIND+SW+( | 6.801 | 2.214 | -0.591 | 7.177 | 0.000 | -0.000 | -0.002 |
| Max rZ | 84 | 4:CONDUCTO | 37.331 | 11.856 | -0.000 | 39.168 | 0.000 | 0.000 | 0.001 |
| Min rZ | 95 | 5:WIND+SW+( | 50.277 | -40.751 | -0.000 | 64.718 | 0.000 | -0.000 | -0.009 |
| Max Rst | 1 | 5:WIND+SW+( | 116.135 | -2.054 | -0.000 | 116.153 | 0.000 | 0.000 | -0.006 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| Number of Nodes | 127 | Highest Node | 127 |
|---|---|---|---|
| Number of Elements | 374 | Highest Beam | 374 |

| Number of Basic Load Cases | 4 |
|---|---|
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 88.690 | -2.054 | -0.000 | 88.714 | 0.000 | 0.000 | -0.005 |
| Min X | 49 | 2:SELF WEIGH | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 62.235 | 20.590 | -0.000 | 65.552 | -0.000 | 0.000 | -0.003 |
| Min Y | 95 | 5:WIND+SW+( | 38.170 | -33.447 | -0.000 | 50.751 | 0.000 | -0.000 | -0.008 |
| Max Z | 68 | 5:WIND+SW+( | 1.178 | -1.035 | 0.860 | 1.789 | -0.001 | -0.000 | 0.000 |
| Min Z | 34 | 5:WIND+SW+( | 1.178 | -1.035 | -0.860 | 1.789 | 0.001 | 0.000 | 0.000 |
| Max rX | 34 | 5:WIND+SW+( | 1.178 | -1.035 | -0.860 | 1.789 | 0.001 | 0.000 | 0.000 |
| Min rX | 68 | 5:WIND+SW+( | 1.178 | -1.035 | 0.860 | 1.789 | -0.001 | -0.000 | 0.000 |
| Max rY | 15 | 5:WIND+SW+( | 5.245 | 1.568 | 0.408 | 5.490 | -0.000 | 0.000 | -0.001 |
| Min rY | 49 | 5:WIND+SW+( | 5.245 | 1.568 | -0.408 | 5.490 | 0.000 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 26.461 | 5.676 | -0.000 | 27.063 | 0.000 | 0.000 | 0.002 |
| Min rZ | 95 | 5:WIND+SW+( | 38.170 | -33.447 | -0.000 | 50.751 | 0.000 | -0.000 | -0.008 |
| Max Rst | 1 | 5:WIND+SW+( | 88.690 | -2.054 | -0.000 | 88.714 | 0.000 | 0.000 | -0.005 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 83.048 | -2.010 | 40.238 | 92.304 | 0.003 | 0.000 | -0.004 |
| Min X | 51 | 3:GW LOAD | -0.156 | -0.178 | 0.098 | 0.256 | 0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 58.989 | 18.504 | 22.982 | 65.956 | 0.003 | -0.000 | -0.002 |
| Min Y | 95 | 5:WIND+SW+( | 36.492 | -31.897 | 11.820 | 49.888 | 0.002 | 0.000 | -0.007 |
| Max Z | 1 | 3:GW LOAD | 7.949 | -0.067 | 40.238 | 41.015 | 0.003 | -0.000 | -0.001 |
| Min Z | 34 | 5:WIND+SW+( | 0.979 | -0.785 | -0.702 | 1.439 | 0.001 | 0.000 | 0.000 |
| Max rX | 1 | 3:GW LOAD | 7.949 | -0.067 | 40.238 | 41.015 | 0.003 | -0.000 | -0.001 |
| Min rX | 68 | 5:WIND+SW+( | 1.337 | -1.220 | 0.964 | 2.050 | -0.001 | -0.000 | 0.000 |
| Max rY | 25 | 5:WIND+SW+( | 31.188 | -3.413 | 9.051 | 32.653 | 0.001 | 0.000 | -0.003 |
| Min rY | 49 | 5:WIND+SW+( | 4.925 | 0.918 | 0.688 | 5.056 | 0.000 | -0.000 | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 26.461 | 5.676 | -0.000 | 27.063 | 0.000 | 0.000 | 0.002 |
| Min rZ | 95 | 5:WIND+SW+( | 36.492 | -31.897 | 11.820 | 49.888 | 0.002 | 0.000 | -0.007 |
| Max Rst | 1 | 5:WIND+SW+( | 83.048 | -2.010 | 40.238 | 92.304 | 0.003 | 0.000 | -0.004 |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 87.243 | -1.957 | 28.923 | 91.933 | 0.002 | 0.003 | -0.005 |
| Min X | 49 | 2:SELF WEIGH | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 60.208 | 22.193 | 47.229 | 79.675 | -0.002 | 0.007 | -0.003 |
| Min Y | 95 | 5:WIND+SW+( | 36.727 | -32.736 | -3.589 | 49.330 | 0.003 | 0.003 | -0.008 |
| Max Z | 106 | 4:CONDUCTO | 37.883 | 12.233 | 47.229 | 61.769 | -0.002 | 0.007 | -0.001 |
| Min Z | 95 | 5:WIND+SW+( | 36.727 | -32.736 | -3.589 | 49.330 | 0.003 | 0.003 | -0.008 |
| Max rX | 105 | 5:WIND+SW+( | 37.830 | -25.717 | -0.717 | 45.749 | 0.003 | 0.003 | -0.006 |
| Min rX | 106 | 5:WIND+SW+( | 60.208 | 22.193 | 47.229 | 79.675 | -0.002 | 0.007 | -0.003 |
| Max rY | 106 | 4:CONDUCTO | 37.883 | 12.233 | 47.229 | 61.769 | -0.002 | 0.007 | -0.001 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 25.018 | 5.112 | 26.180 | 36.571 | -0.000 | 0.003 | 0.002 |
| Min rZ | 95 | 5:WIND+SW+( | 36.727 | -32.736 | -3.589 | 49.330 | 0.003 | 0.003 | -0.008 |
| Max Rst | 1 | 5:WIND+SW+( | 87.243 | -1.957 | 28.923 | 91.933 | 0.002 | 0.003 | -0.005 |

| | | Job No | Sheet No | Rev |
|---|---|---|---|---|
| Software licensed to | | | 1 | |
| | | Part | | |
| Job Title | 275 kV Double Circuit (IS 802) | Ref | (WIND+SelfWeight+Security- MC Broken Condition) | |
| | | By | Shafiq | Date 08-Nov-11 Chd |
| Client | Final Year Project (Civil Engineering UTP) | File | 275kv with arm IS 802 wi | Date/Time 06-Dec-2011 01:52 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| Structure Type | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | **88.840** | -1.985 | 14.875 | 90.098 | 0.001 | 0.002 | -0.005 |
| Min X | 49 | 2:SELF WEIGH | **-0.075** | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 61.983 | **21.057** | 26.180 | 70.503 | 0.002 | 0.003 | -0.003 |
| Min Y | 95 | 5:WIND+SW+( | 37.506 | **-33.909** | -14.672 | 52.648 | 0.001 | 0.005 | -0.008 |
| Max Z | 84 | 4:CONDUCTO | 25.425 | 9.109 | **36.481** | 45.390 | -0.004 | 0.007 | 0.000 |
| Min Z | 95 | 5:WIND+SW+( | 37.506 | -33.909 | **-14.672** | 52.648 | 0.001 | 0.005 | -0.008 |
| Max rX | 83 | 4:CONDUCTO | 14.027 | -12.145 | -3.351 | 18.855 | **0.002** | 0.002 | -0.003 |
| Min rX | 84 | 4:CONDUCTO | 25.425 | 9.109 | 36.481 | 45.390 | **-0.004** | 0.007 | 0.000 |
| Max rY | 84 | 4:CONDUCTO | 25.425 | 9.109 | 36.481 | 45.390 | -0.004 | **0.007** | 0.000 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | **-0.000** | -0.000 |
| Max rZ | 70 | 4:CONDUCTO | 14.970 | 5.098 | 16.547 | 22.889 | -0.001 | 0.002 | **0.001** |
| Min rZ | 95 | 5:WIND+SW+( | 37.506 | -33.909 | -14.672 | 52.648 | 0.001 | 0.005 | **-0.008** |
| Max Rst | 1 | 5:WIND+SW+( | 88.840 | -1.985 | 14.875 | **90.098** | 0.001 | 0.002 | -0.005 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| All | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 89.157 | -2.005 | 7.069 | 89.459 | 0.000 | 0.001 | -0.005 |
| Min X | 49 | 2:SELF WEIGH | -0.075 | -0.218 | 0.073 | 0.241 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 5:WIND+SW+( | 62.470 | 20.866 | 13.262 | 67.184 | 0.001 | 0.002 | -0.003 |
| Min Y | 95 | 5:WIND+SW+( | 38.192 | -33.652 | -7.475 | 51.449 | -0.001 | 0.002 | -0.008 |
| Max Z | 70 | 4:CONDUCTO | 14.940 | 7.907 | 19.366 | 25.706 | -0.002 | 0.004 | -0.000 |
| Min Z | 77 | 5:WIND+SW+( | 21.253 | -26.430 | -9.297 | 35.166 | 0.001 | 0.003 | -0.005 |
| Max rX | 94 | 5:WIND+SW+( | 39.807 | 14.538 | 14.659 | 44.842 | 0.001 | 0.002 | -0.001 |
| Min rX | 70 | 4:CONDUCTO | 14.940 | 7.907 | 19.366 | 25.706 | -0.002 | 0.004 | -0.000 |
| Max rY | 70 | 5:WIND+SW+( | 22.655 | 13.743 | 19.366 | 32.820 | -0.002 | 0.004 | -0.002 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 26.486 | 5.965 | 16.547 | 31.795 | 0.001 | 0.002 | 0.002 |
| Min rZ | 95 | 5:WIND+SW+( | 38.192 | -33.652 | -7.475 | 51.449 | -0.001 | 0.002 | -0.008 |
| Max Rst | 1 | 5:WIND+SW+( | 89.157 | -2.005 | 7.069 | 89.459 | 0.000 | 0.001 | -0.005 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | **28.260** | -3.981 | 20.119 | 34.918 | 0.002 | -0.000 | -0.001 |
| Min X | 51 | 4:CONDUCTO | **-0.173** | -0.170 | 0.171 | 0.296 | -0.000 | -0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 14.488 | **5.732** | 0.000 | 15.581 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND+SW+( | 10.831 | **-30.084** | 5.910 | 32.516 | 0.001 | 0.000 | -0.011 |
| Max Z | 1 | 3:GW LOAD | 0.703 | -0.181 | **20.119** | 20.132 | 0.002 | -0.000 | -0.000 |
| Min Z | 34 | 5:WIND+SW+( | 0.689 | -0.522 | **-0.485** | 0.991 | 0.001 | 0.000 | 0.000 |
| Max rX | 1 | 5:WIND+SW+( | 28.260 | -3.981 | 20.119 | 34.918 | **0.002** | -0.000 | -0.001 |
| Min rX | 68 | 5:WIND+SW+( | 0.867 | -0.740 | 0.616 | 1.296 | **-0.001** | -0.000 | 0.000 |
| Max rY | 22 | 5:WIND+SW+( | 16.137 | -3.755 | 8.336 | 18.547 | 0.001 | **0.000** | -0.001 |
| Min rY | 5 | 5:WIND+SW+( | 16.686 | -1.451 | 8.400 | 18.737 | 0.001 | **-0.000** | -0.001 |
| Max rZ | 84 | 4:CONDUCTO | 5.586 | -19.639 | -0.000 | 20.418 | 0.000 | 0.000 | **0.010** |
| Min rZ | 95 | 5:WIND+SW+( | 10.831 | -30.084 | 5.910 | 32.516 | 0.001 | 0.000 | **-0.011** |
| Max Rst | 1 | 5:WIND+SW+( | 28.260 | -3.981 | 20.119 | **34.918** | 0.002 | -0.000 | -0.001 |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| **Name:** | Shafiq | | |
| **Date:** | 08-Nov-11 | | |

| | |
|---|---|
| **Structure Type** | SPACE FRAME |

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| | |
|---|---|
| **All** | The Whole Structure |

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | 36.327 | -3.875 | 28.928 | 46.599 | 0.002 | 0.003 | -0.002 |
| Min X | 15 | 4:CONDUCTO | -0.349 | 0.075 | 1.577 | 1.617 | 0.000 | 0.000 | -0.000 |
| Max Y | 106 | 1:WIND FROM | 14.488 | 5.732 | 0.000 | 15.581 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND+SW+( | 12.154 | -31.988 | -3.589 | 34.407 | 0.003 | 0.003 | -0.012 |
| Max Z | 106 | 4:CONDUCTO | 9.477 | -2.289 | 47.236 | 48.232 | -0.002 | 0.007 | 0.002 |
| Min Z | 95 | 5:WIND+SW+( | 12.154 | -31.988 | -3.589 | 34.407 | 0.003 | 0.003 | -0.012 |
| Max rX | 105 | 5:WIND+SW+( | 13.839 | -21.810 | -0.717 | 25.840 | 0.003 | 0.003 | -0.008 |
| Min rX | 106 | 5:WIND+SW+( | 24.789 | 2.964 | 47.236 | 53.428 | -0.002 | 0.007 | 0.001 |
| Max rY | 106 | 5:WIND+SW+( | 24.789 | 2.964 | 47.236 | 53.428 | -0.002 | 0.007 | 0.001 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | -0.000 | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.700 | -17.684 | 26.184 | 32.298 | -0.000 | 0.003 | 0.010 |
| Min rZ | 95 | 5:WIND+SW+( | 12.154 | -31.988 | -3.589 | 34.407 | 0.003 | 0.003 | -0.012 |
| Max Rst | 106 | 5:WIND+SW+( | 24.789 | 2.964 | 47.236 | 53.428 | -0.002 | 0.007 | 0.001 |

| | | | | |
|---|---|---|---|---|
| Software licensed to | | Job No | Sheet No 1 | Rev |
| | | Part | | |
| Job Title 275 kV Double Circuit (IS 802) | | Ref (WIND+SelfWeight+Safety - MC Broken Condition) | | |
| | | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | | File 275kv with arm IS 802 wi | Date/Time 06-Dec-2011 01:46 | |

# Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

# Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | **34.567** | -3.931 | 14.877 | 37.837 | 0.001 | 0.002 | -0.002 |
| Min X | 13 | 4:CONDUCTO | **-0.913** | -0.313 | 2.138 | 2.346 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 14.488 | **5.732** | 0.000 | 15.581 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND+SW+( | 12.512 | **-32.672** | -14.675 | 37.938 | 0.001 | 0.005 | -0.012 |
| Max Z | 84 | 4:CONDUCTO | 6.427 | -11.811 | **36.486** | 38.885 | -0.004 | 0.007 | 0.007 |
| Min Z | 95 | 5:WIND+SW+( | 12.512 | -32.672 | **-14.675** | 37.938 | 0.001 | 0.005 | -0.012 |
| Max rX | 83 | 4:CONDUCTO | 1.731 | -9.389 | -3.350 | 10.118 | **0.002** | 0.002 | -0.004 |
| Min rX | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | **-0.004** | 0.007 | 0.007 |
| Max rY | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | -0.004 | **0.007** | 0.007 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | **-0.000** | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 6.427 | -11.811 | 36.486 | 38.885 | -0.004 | 0.007 | **0.007** |
| Min rZ | 95 | 5:WIND+SW+( | 12.512 | -32.672 | -14.675 | 37.938 | 0.001 | 0.005 | **-0.012** |
| Max Rst | 84 | 5:WIND+SW+( | 16.403 | -7.120 | 36.486 | **40.632** | -0.004 | 0.007 | 0.006 |

| Software licensed to | Job No | Sheet No 1 | Rev |
|---|---|---|---|
| | Part | | |
| Job Title 275 kV Double Circuit (IS 802) | Ref (WIND+SelfWeight+Safety - BC Brokenl Condition) | | |
| | By Shafiq | Date 08-Nov-11 | Chd |
| Client Final Year Project (Civil Engineering UTP) | File 275kv with arm IS 802 wi | Date/Time 06-Dec-2011 01: | |

## Job Information

| | Engineer | Checked | Approved |
|---|---|---|---|
| Name: | Shafiq | | |
| Date: | 08-Nov-11 | | |

| Structure Type | SPACE FRAME |
|---|---|

| | | | |
|---|---|---|---|
| Number of Nodes | 127 | Highest Node | 127 |
| Number of Elements | 374 | Highest Beam | 374 |

| | |
|---|---|
| Number of Basic Load Cases | 4 |
| Number of Combination Load Cases | 1 |

*Included in this printout are data for:*

| All | The Whole Structure |
|---|---|

*Included in this printout are results for load cases:*

| Type | L/C | Name |
|---|---|---|
| Primary | 1 | WIND FROM LEFT |
| Primary | 2 | SELF WEIGHT |
| Primary | 3 | GW LOAD |
| Primary | 4 | CONDUCTOR LOAD |
| Combination | 5 | WIND+SW+GW LOAD+CONDUCTOR LC |

## Node Displacement Summary

| | Node | L/C | X (mm) | Y (mm) | Z (mm) | Resultant (mm) | rX (rad) | rY (rad) | rZ (rad) |
|---|---|---|---|---|---|---|---|---|---|
| Max X | 1 | 5:WIND+SW+( | **32.452** | -3.971 | 7.070 | 33.450 | 0.000 | 0.001 | -0.002 |
| Min X | 13 | 4:CONDUCTO | **-1.348** | -0.467 | 1.521 | 2.086 | 0.000 | 0.001 | 0.000 |
| Max Y | 106 | 1:WIND FROM | 14.488 | **5.732** | 0.000 | 15.581 | 0.000 | 0.000 | -0.001 |
| Min Y | 95 | 5:WIND+SW+( | 12.686 | **-31.265** | -7.477 | 34.560 | -0.001 | 0.002 | -0.012 |
| Max Z | 70 | 4:CONDUCTO | 4.083 | -9.305 | **19.369** | 21.872 | -0.002 | 0.004 | 0.004 |
| Min Z | 77 | 5:WIND+SW+( | 6.427 | -24.595 | **-9.298** | 27.068 | 0.001 | 0.003 | -0.007 |
| Max rX | 94 | 5:WIND+SW+( | 15.434 | -6.514 | 14.661 | 22.262 | **0.001** | 0.002 | 0.005 |
| Min rX | 70 | 4:CONDUCTO | 4.083 | -9.305 | 19.369 | 21.872 | **-0.002** | 0.004 | 0.004 |
| Max rY | 70 | 5:WIND+SW+( | 10.049 | -5.527 | 19.369 | 22.510 | -0.002 | **0.004** | 0.003 |
| Min rY | 66 | 1:WIND FROM | 1.677 | -0.520 | 0.142 | 1.761 | -0.000 | **-0.000** | -0.000 |
| Max rZ | 84 | 4:CONDUCTO | 7.237 | -18.527 | 16.550 | 25.875 | 0.001 | 0.002 | **0.010** |
| Min rZ | 95 | 5:WIND+SW+( | 12.686 | -31.265 | -7.477 | 34.560 | -0.001 | 0.002 | **-0.012** |
| Max Rst | 95 | 5:WIND+SW+( | 12.686 | -31.265 | -7.477 | **34.560** | -0.001 | 0.002 | -0.012 |